SEP 24 1923

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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

OFFICES FOR ADVERTISEMENTS AND PUBLICATION, 35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.2.

VOL. CXVI.—No. 3010.] *LONDON: FRIDAY, SEPTEMBER 7, 1923.* [*Registered at the General Post Office as a Newspaper.*] [PRICE ... 1s. BY FOREIGN POST 1s. 4d.

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See advertisement page 18.
PATENT WATER-TUBE BOILERS.
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See Advertisement last week, page 88.

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Naval Outfits a Speciality, also for Merchant Ships, for Factories, Locomotives, and Industrial Process Furnaces of all kinds.
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See Advertisement, page 60. 1111

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YARROW BOILERS.
1553

Matthew Paul & Co., Ltd.,
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See Full Page Advt., page 60, Aug. 17.

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For Production of SHEET METAL WORK, COINAGE, CARTRIDGES AND GUNPOWDER.
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See advert., page 59, Aug. 17. 8195

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See Advertisement page 68. 2402

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See half-page Advertisement, page 66, Aug. 31.

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For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.

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(COLEG PRIFATHROFAOL DEHEUDIR CYMRU AND MYNWY).

The Council of the College invites

Applications for the Post of

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Further particulars regarding the above post may be obtained from the undersigned.

D. J. A. BROWN,
Registrar.

University College, Cardiff,
August 20, 1923. B 403

Finsbury Technical College,

LEONARD STREET, CITY ROAD, E.C. 2.

CIVIL AND MECHANICAL ENGINEERING.
Professor H. P. PHILPOT, A.M.Inst.C.E.
ELECTRICAL ENGINEERING.
Professor W. H. HOCKLES, DSc., F.R.S.
CHEMISTRY.
Professor A. G. HALE, F.I.C.

The College provides practical scientific training for students who desire to become Civil, Mechanical or Electrical Engineers or Chemists.

Candidates are required to pass an Entrance Examination in Mathematics and English, but the Matriculation Certificate of any British University, and certain other qualifications, are accepted in lieu of it. The next Entrance Examination will be held on Tuesday, 18th September. Applications for admission should be forwarded to the College on forms to be obtained from the REGISTRAR. The Programme of the College may be had on application. B 47

City of Cardiff Education COMMITTEE.

THE TECHNICAL COLLEGE.
Principal: CHARLES COLES, B.Sc. (Lond.).

DEPARTMENT OF ENGINEERING.
Head of Department: A. W. LOVERIDGE, B.Sc. (Eng.), A.R.C.Sc.

SESSION 1923-24.
(Commencing on Tuesday, 2nd October, 1923).

The following Courses have been arranged for Engineering students:—

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A Two-Years' Course for apprentices and others with facilities for practical experience in the Summer Term.

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For further particulars of Full-time and Part-time Courses, Entrance Examination, Scholarships, Fees, etc., apply to the PRINCIPAL. Application forms for Entrance Scholarship Examination, duly filled up, must be received before September 17th.

JOHN J. JACKSON, Director of Education, City Hall, Cardiff. B 386

The University of Sheffield.

SESSION 1923-24.

Vice-Chancellor: Sir HENRY HADOW, C.B.E., D.Mus., LL.D.

DEPARTMENTS OF MECHANICAL, ELECTRICAL AND CIVIL ENGINEERING, METALLURGY MINING, FUEL TECHNOLOGY, AND GLASS TECHNOLOGY.

The Courses in the DEPARTMENT of ENGINEERING extend over three or four years and prepare students to become Mechanical, Electrical, Civil or Mining Engineers, or specialists in Fuel Technology or Glass Technology.

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The LECTURE COURSES in all the Departments are supplemented by practical Training in Laboratories and Workshops, which are fully equipped for the purpose of advanced scientific teaching, investigation and research.

Part-time courses are arranged for students who desire to take special portions of any of the regular courses.

In Mining Engineering and in certain of the Courses in Mechanical and Electrical Engineering, and in Glass Technology, arrangements are made to enable students, who come to the University from works or collieries, to take six months' courses of study at the University and six months' practice at the Works or Colliery each year for a period of four years.

The LECTURE COURSES commence OCTOBER 3rd, 1923.

The TECHNICAL LABORATORY COURSES commence SEPTEMBER 25th, 1923.

For further details of the Courses and for particulars of the Degrees, Associateships, Diplomas, and Certificates awarded on their successful completion, application should be made to

W. M. GIBBONS,
Registrar.

B 444

Civil Service Commission.

FORTHCOMING EXAMINATION.

PROBATIONARY ASSISTANT ENGINEER in the Engineer-in-Chief's Department of the General Post Office (20-25, with extension in certain cases), 27th September.

The date specified is the latest on which applications can be received. They must be made on forms to be obtained, with particulars, from THE SECRETARY, CIVIL SERVICE COMMISSION, Burlington Gardens, London, W. 1. B 388

The Yarrow Scholarships.

The COUNCIL of the INSTITUTION OF CIVIL ENGINEERS are PREPARED to CONSIDER APPLICATIONS for NOMINATIONS to the above SCHOLARSHIPS.

These should be submitted before the 1st October, 1923, to the SECRETARY of the Institution, at Great George Street, Westminster, S.W. 1, from whom the detailed regulations may be had on application.

The Yarrow Scholars must be British subjects who, desiring to become Engineers, lack sufficient means to enable them to pursue their practical or scientific training.

The Scholarships are of a value varying from £50-£100 per annum. B 162

ENGINEERING AND TECHNICAL OPTICS.

Northampton Polytechnic INSTITUTE, St. John Street, London, E.C.1.

ENGINEERING DAY COLLEGE.

Full-time Day Courses in the Theory and Practice of Civil, Mechanical, and Electrical Engineering. The Courses in Civil and Mechanical Engineering include specialisation in Automobile and AERONAUTICAL Engineering, and those in Electrical Engineering include specialisation in RADIO-TELEGRAPHY.

A SPECIAL ENTRANCE EXAMINATION is held at the end of September before the commencement of each Session. The Courses include periods spent in commercial workshops and extend over four years. They also prepare for the Degree of B.Sc. in Engineering at the University of London. Fees £18 or £13 per annum.

THREE ENTRANCE SCHOLARSHIPS of the value of £62 each for the complete course will be offered for competition at the annual entrance examination in September.

OPTICAL ENGINEERING AND TECHNICAL OPTICS.

Full and Part-time Courses in this important department of Applied Science are given in specially equipped laboratories and lecture rooms. The annual entrance examination is held at the end of September.

EVENING TECHNICAL COURSES

in all branches of Mechanical and Electrical Engineering commences on Monday, September 24th 1923.

The Laboratories, both Mechanical and Electrical, are well equipped with modern apparatus which, on the Mechanical side, provides for specialisation in Automobile and Aeronautical Engineering and, on the Electrical side, for specialisation in Alternate and Continuous Current Work, in Radio-Telegraphy and Telephony, and in Electrical Testing.

More complete particulars, together with conditions of entrance, etc., and all information respecting the work of the Institute can be obtained at the Institute, or on application to—

R. MULLINEUX WALMSLEY, D.Sc.
Principal.
B 511

The Sir John Cass Technical INSTITUTE.

JEWRY STREET, ALDGATE, E.C. 3.

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DEPARTMENT OF METALLURGY.

Evening Classes for those engaged in Metallurgical Industries, Prospectors, those intending to take up Metallurgical and Mining Work in the Colonies, Engineers and Works' Analysts.

STAFF:—

Head of the Department:—

GEO. PATCHIN, A.R.S.M., M.I.M.M.

Lecturers:—

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O. F. HUDSON, D.Sc., A.R.C.S.
L. SINGLEHURST WARD, B.Sc.
W. R. SCHOELLER, Ph.D., A.I.C.
A. F. GIBBS.

The following Courses of Lectures, accompanied by suitable laboratory work, will be given during the session:—

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Assaying—Mineralogy.
Metallurgy of Iron and Steel.
Metallography and Pyrometry.
Foundry Practice.
Heat Treatment of Metals and Alloys.
Mechanical Testing of Metals and Alloys.
Analysis of Engineering Works Material.
Mining—Surveying.

SESSION commences
THURSDAY, SEPTEMBER 20th.

ENROLMENT—Monday, Tuesday and Wednesday, September 17th, 18th and 19th, between Six and 8.30 p.m.

Detailed Syllabus may be had upon application at the Office of the Institute, or by letter to the PRINCIPAL. B 510

University of Manchester.

DEPARTMENT OF ELECTRICAL ENGINEERING.

Departments of Civil, Mechanical and Electrical Engineering.

Full particulars of these Courses will be forwarded on application to the INTERNAL REGISTRAR.

The Session commences on October 4th. B 345

The Polytechnic, 309, Regent STREET, W.1.

A SPECIAL COURSE has been arranged for students taking the STUDENTSHIP EXAMINATION OF THE INSTITUTION OF MECHANICAL ENGINEERS, the PRELIMINARY EXAMINATION OF THE INSTITUTION OF CIVIL ENGINEERS, and the FINAL EXAMINATION OF THE INSTITUTION OF ELECTRICAL ENGINEERS (PART I).

The classes are as follows:—

PURE MATHEMATICS	Monday,	8.0.—9.30.
ENGLISH - - -	,,	6.30.—8.0.
MECHANICS - - -	Thursday,	8.0.—9.30.
FRENCH - - -	,,	6.30.—8.0.
PHYSICS - - -	Wednesday,	6.30.—9.0.

The Syllabus covers all the work in these subjects required for the examinations mentioned.

Fee for the Course, £2 2s.

Prospectus free on application to the DIRECTOR OF EDUCATION. B 380

Borough Polytechnic INSTITUTE,

Borough Road, London, S.E. 1.

ENGINEERING DEPARTMENT.

Under the direction of GEO. R. DRAYCOTT, Wh. Ex., A.M.I.M.E.

REINFORCED CONCRETE DESIGN
(Lectures and Drawing Office Work).

By STANLEY VAUGHAN, B.Sc. (Hons. Eng.), A.M.I.C.E. Thursday, 7.15 to 9.45 p.m.

Commencing on September 26th, 1923.

Note:—This forms part of the Fifth Year's work of the Recognised Course in Structural Engineering for the National Certificate, but qualified non-course students may be admitted upon application to the Head of the Department or to

J. W. BISPHAM, O.B.E., M.A., B.Sc.
(Principal.) B 383

Battersea Polytechnic, London, S.W.11.

Principal: ROBERT H. PICKARD, D.Sc., F.R.S.

ENGINEERING DEPARTMENT.

Evening Classes Suitable for Final B.Sc. (Eng.), A.M.I.C.E., A.M.I.M.E., etc., are held in the following subjects:—

STRENGTH OF MATERIALS with LABORATORY TESTING. THEORY OF STRUCTURES and STRUCTURAL DESIGN. THEORY OF MACHINES and MACHINE DESIGN. HEAT ENGINES with LABORATORY TESTING. HYDRAULICS with LABORATORY TESTING.

Students enrolled from September 18th.

DAY TECHNICAL COLLEGE.

Full Time Courses in MECHANICAL, CIVIL, and ELECTRICAL ENGINEERING for B.Sc. (Eng.) Degree, (UNIVERSITY OF LONDON) or COLLEGE DIPLOMA commence September 24th. ENTRANCE EXAMINATION commences September 18th. Fee: £18 per session. A higher fee will be charged to students not residing in London.

Full Particulars of all classes on application to the PRINCIPAL. B 512

Correspondence Courses for

Inst. Civil Engrs., Inst. Mech. E., London Univ. (Matric., Inter., B.Sc.), and All ENGINEERING EXAMINATIONS personally conducted by Mr. TREVOR W. PHILLIPS, B.Sc. (Honours), Assoc. M.Inst.C.E., M.R.S.I., F.R.S.A., &c. Also Day Tuition in Office. Excellent results at all Exams. Courses may commence at any time, and all Students receive individual tuition.—For full particulars apply to 8/11, TRAFFORD CHAMBERS, 58, SOUTH JOHN STREET, LIVERPOOL. 1296

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Power and Speed of Vessels.

—Practical Course of Instruction by Correspondence.—Address, for particulars and terms, 1463, Offices of ENGINEERING.

Structural Engineering.—A

Civil Engineer GIVES INSTRUCTION, by post, in the Computation of Stresses in Girders, Columns & Trusses.—B 472, Offices of ENGINEERING.

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UNION INFIRMARY, STOTT LANE, WHASTE.

THE SALFORD BOARD OF GUARDIANS invite

Tenders for Heating and Hot

Water SERVICE APPARATUS, including Calorifiers, Pumps, Mains, Radiators and the like, for the above Infirmary and Nurses Home Extension.

Drawings of the Plant may be inspected at the Offices of the Engineer, Mr. T. ROLAND WOLLASTON, M.I.M.E., Lord's Chambers, 26, Corporation Street, Manchester, on or after Monday, August 27th, between the hours of Ten a.m. and Four p.m. Specification, Form of Tender and Conditions of Contract may be obtained from the undersigned on receipt of written application enclosing cheque value Two Guineas, which sum will be refunded on due receipt of *bona fide* Tender.

The Board do not bind themselves to accept the lowest or any Tender. The selected Contractor will be required to subscribe to the conditions as regards employment of labour, etc., as set forth in the Board's Regulations.

Sealed Tenders endorsed "Engineering Section 2," must be delivered at my Offices not later than Ten a.m. on Saturday, September 22nd, 1923.

E. H. INCHLEY,
Clerk to the Guardians.

Poor Law Offices,
Eccles New Road, Salford.
23rd August, 1923. B 439

THE GREAT INDIAN PENINSULA RAILWAY COMPANY.

The Directors are prepared to receive

Tenders for the Supply of the

following STORES, namely:—

	Fee for Specification.
1. STEEL FISHPLATES	£1
2. STEEL FISHBOLTS	10/-

Specifications and Forms of Tender may be obtained at this office on payment of the fee for the Specification, which payment will not be returned.

The fee should accompany any application by post. Cheques and Postal Orders should be crossed and made payable to the Great Indian Peninsula Railway Company.

Tenders must be delivered in separate envelopes, sealed and addressed to the undersigned marked "Tender for Steel Fishplates," or, as the case may be, not later than Eleven o'clock a.m., on Tuesday, the 18th September, 1923.

The Directors do not bind themselves to accept the lowest or any Tender.

R. H. WALPOLE,
Secretary,

Company's Offices,
48, Copthall Avenue, E.C. 2.
London, 5th September, 1923. B 510

AGENT-GENERAL FOR VICTORIA (AUSTRALIA),
Melbourne Place, Strand,
London, W.C. 2.

CONSTRUCTION OF BRIDGE FOR COUNTRY ROADS BOARD, VICTORIA.

Tenders, Addressed to

The AGENT-GENERAL, and endorsed "Tender for Barwon River Bridge," will be received at this Office until TWELVE o'clock Noon on Wednesday, 24th October next, for the ERECTION of a BRIDGE over the Barwon River at Geelong, Victoria, consisting of 417 lin. ft. of deck plate girder bridge, with concrete deck, 1200 lin. ft. of approaches and 16,000 cubic yards of river excavation.

Plans and Specifications may be inspected at this Office. The lowest or any Tender not necessarily accepted. Preliminary deposit £500. B 395

H.E.H. THE NIZAM'S GUARANTEED STATE RAILWAYS COMPANY, LIMITED.

The Directors of H.E.H. The Nizam's Guaranteed State Railways Company, Limited, are prepared to receive

Tenders for the Supply of

about
135 Tons of STEEL MATERIAL (Angles, Hoops, Rounds, Squares, etc.).

For each Copy of the Specification a Fee of Ten Shillings will be charged, which is not returnable.

Tenders, enclosed in sealed envelopes, addressed to the Chairman and Directors, and endorsed "Tender for Steel Material," must be delivered at the Company's Offices not later than Twelve Noon on FRIDAY, 14th September, 1923.

The Directors do not bind themselves to accept the lowest or any Tender.

F. ADAMS, Secretary.

271, Winchester House,
Old Broad Street,
London, E.C.2, 3rd September, 1923. B 537

THE SOUTH INDIAN RAILWAY COMPANY LIMITED,
are prepared to receive

Tenders for the Supply of:—

STRUCTURAL STEELWORK for Wagon Repair Shop, Trichinopoly Workshops Scheme.

Specifications and forms of Tender will be available at the Company's Offices, 91, Petty France, Westminster, S.W. 1.

Tenders addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked "Tenders for Structural Steelwork Wagon Repair Shop," must be left with the undersigned not later than Twelve Noon, on Friday, the 9th November, 1923.

The Directors do not bind themselves to accept the lowest or any Tender.

A charge, which will not be returned, will be made of £1 for each copy of the Specification.

Copies of the Drawings may be obtained at the offices of Messrs. ROBERT WHITE & PARTNERS, Consulting Engineers to the Company, 3, Victoria Street, Westminster, S.W. 1.

A. MUIRHEAD,
Managing Director.

91, Petty France, S.W.1.
4th September, 1923. B 562

Tenders will be Received

at the Office of the Colonial Secretary, in Singapore, S.S. on or before the 30th November, 1923—due allowance being made for delays in the Post.

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RECIPROCAL LOAD DEFLECTION RELATIONSHIPS FOR STRUCTURES.

By C. E. LARARD, Wh.Exh., M.Inst.C.E., M.Inst.Mech.E.

Preliminary.—Three papers* by the late Lord Rayleigh express in exact mathematical language some important theorems or relationships of value to engineering students and practical engineers who have to make calculations of the deformations of elastic structures. His first reciprocal relationship is, of course, well known and much used by engineers; but, in using an established and isolated result without a consideration of the fundamental principles leading up to that result, its value as an instrument of utility becomes less flexible and more limited in its application.

The writer proposes, therefore, after making the necessary references to Lord Rayleigh's work to present some of the results obtained, and to extend them, in a form which, though less mathematical, is, nevertheless, more in accordance with engineering usage, and to give such selected examples which suggest themselves to him for the purpose of making clear the fundamental principles involved and the use to which the theorems can be applied.

Lord Rayleigh states: "I proved a very general reciprocal property of systems capable of vibrating, with or without dissipation, about a position of stable equilibrium. The principle may be shortly, though rather imperfectly, stated thus: If a periodic force of harmonic type and of given amplitude and period act upon a system at a point P, the resulting displacement at a second point Q will be the same both in amplitude and phase as it would be at the point P were the force to act at Q. If we suppose the period of the force to be very great, the effects both of dissipation and inertia will ultimately disappear, and the system will be in a condition of what is called movable equilibrium; that is to say, it will be found at any moment in that configuration in which it would be maintained at rest by the then acting forces, supposed to remain unaltered. The statical theorem to which the general principle then reduces is so extremely simple that it can hardly be supposed to be altogether new."

He then considers the statical problem as a special case of his more general result, and after stating his first reciprocal relationship in mathematical terms takes by way of example a rod maintained in a horizontal position and asserts that a pound weight hung at one point will give the same deflection at any other point that it would at the first point if the pound weight were placed at the second point, *i.e.*, a force P acting at a point A produces the same deflection at any other point B that would be produced at A if the force P acted at B instead of A. Rayleigh adds that: "The only thing on which our conclusion depends is the proportionality of strains and stresses." As another illustration of the application of the principle he states: "If we take angular instead of linear displacements, a given couple at A will produce the same rotation at B as the couple at B would give at A. Or if one displacement be linear and the other angular, a couple at A would do as much work in acting over the rotation at A due to a simple force at B as the force of B would do in acting over the same linear displacement at B due to the couple at A."

Lord Rayleigh states the second and third propositions or reciprocal relationships in mathematical terms, and illustrates them as for the first proposition by taking the example of a rod thus: "If the rod be supported at A so that the point cannot fall, while B is depressed 1 in. by a force there acting, the reaction on the support at A is the same as it would have been on a support at B if A had been depressed 1 in. If the rod is supported at A and bent by a force acting downwards at B the reaction bears the same ratio to the force as the displacement at B would bear to the displacement at A when the unsupported rod is bent by a force applied at A."

He also pointed out that all three propositions "admit of extension to the vibration of systems subject to inertia and dissipation."

* *Phil. Mag.*, xlviii, 1874; xlix, 1875. Math. Soc., 1873. See also articles 32 and 35, "Scientific Papers," vol. i.

Although the case of an elastic rod was considered by way of example, yet the general investigation given includes the case of an elastic structure or a curved, as well as an initially straight, unit or part of an elastic structure.

The papers referred to give some experimental results demonstrating the truth of the propositions, and the following suggestion made has long been adopted both in the laboratory and in practical work:—

"The theorem here verified might sometimes be useful in determining the curve of deflection of a bar when loaded at any point A. Instead of observing the deflections at a number of points it might be simpler to measure the deflections of a fixed point A, while the load is shifted to the various points."

At the conclusion of article No. 32* appears the

Fig. 1.

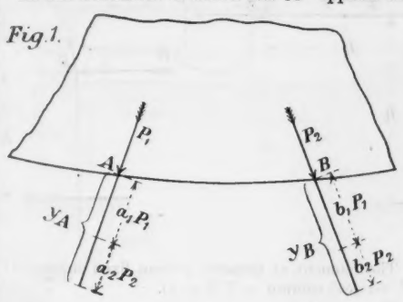


Fig. 2.

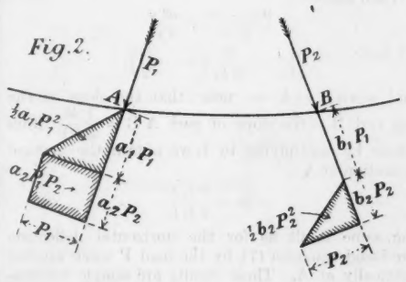
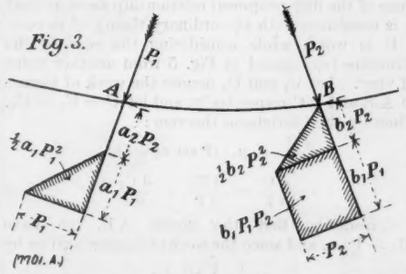


Fig. 3.



following presentation due to Professor Everett: "A weight W applied at the point A produces a drop a at A and a drop b at B; while a weight W^1 applied at B produces a drop a^1 at A and b^1 at B.

"If both weights be in operation, the potential energy of deformation is definite, and its value may be arrived at in two ways by applying the weights in different orders. If we first apply W, the potential energy so far is $\frac{1}{2} W a$; and if we then apply W^1 the additional potential energy is $\frac{1}{2} W^1 b^1 + W a^1$, making altogether $\frac{1}{2} W a + \frac{1}{2} W^1 b^1 + W a^1$. In like manner if the order of application be reversed, we find $\frac{1}{2} W a + \frac{1}{2} W^1 b^1 + W^1 b$. $\therefore W a^1 = W^1 b$."

If $W^1 = W$ then $a^1 = b$, *i.e.*, displacement at A due to W at B = displacement at B due to W at A.

Statement of the Three Reciprocal Relationships.—Considering any elastic structure with ends fixed or hinged, or one end fixed and one hinged to immovable supports, we have:—

(I) The displacement at any point A due to a load P applied at any other point B is equal to the displacement at B due to the same load P if placed at A instead of at B.

* "Scientific Papers of Lord Rayleigh," vol. i, page 229.

(II) If displacement at a point A is prevented by a load P at A with displacement y_B at B under a load Q; and alternatively if a load Q_1 at B prevents displacement at B with displacement y_A at A under a load P^1, then if $y_A = y_B$, P must equal Q_1.

(III) If a force Q acts at any point B producing displacements y_B at B and y_A at any other point A, and if a second force P is caused to act at A but in the opposite direction to Q reducing the displacement at B to zero, then $\frac{Q}{P} = \frac{y_A}{y_B}$

In these three relationships it is understood that the displacements are in the directions of the acting forces and are not of necessity the absolute displacements.

Work of Deformation and Proof of Relationships.—Hookes' law that strain is proportional to stress or load and the theorem that the deflection at any point due to several loads is equal to the algebraic sum of the deflections at that point due to the loads considered separately we shall interpret in their most general sense as applying to any elastic structure. Thus, referring to Fig. 1, which represents any elastic structure or girder, framed or otherwise:—

Displacement at A due to P_1 at A $\propto P_1 = a_1 P_1$
Displacement at A due to P_2 at B $\propto P_2 = a_2 P_2$
Total displacement at A due to both
$= y_A = a_1 P_1 + a_2 P_2$ . . . (1)

Similarly
Displacement at B due to P_1 at A $\propto P_1 = b_1 P_1$
Displacement at B due to P_2 at B $\propto P_2 = b_2 P_2$
Total displacement at B due to both
$= y_B = b_1 P_1 + b_2 P_2$ . . (2)

The coefficients a, a_1, b, b_1, are the displacements per unit force.

If P_1 and P_2 are vertical loads then the displacements become the vertical deflections.

Referring to Fig. 2, let P_1 be applied gradually from zero magnitude to its maximum value P_1 before P_2 is applied.

Then displacement at A $= a_1 P_1$ and work done $= \frac{1}{2} a_1 P_1^2$.

Now apply P_2 gradually at $B_1 - P_1$, being constant at A.

The additional displacement $A = a_2 P_2$ and the additional work done at $A = a_2 P_1 P_2$, while the work done by P_2 at $B = \frac{1}{2} b_2 P_2^2$.

If the centre of gravity of the structures falls through $\bar{y}$ then gravity does work $= W \bar{y}$, where W = weight of structure.

The total work done in deforming the structure

$= \frac{1}{2} a_1 P_1^2 + \frac{1}{2} b_2 P_2^2 + a_2 P_1 P_2 + W \bar{y}$ . . (3)

Next reverse the order of application of the loading and, applying P_2, first with P_1 removed, we obtain (see Fig. 3):—

Displacement at B due to $P_2 = b_2 P_2$
Work done at $B = \frac{1}{2} b_2 P_2^2$
Applying P_1 at A.
Displacement at A due to $P_1 = a_1 P_1$
Work at $A = \frac{1}{2} a_1 P_1^2$
Additional work at B due to drop of $B = b_1 P_1 P_2$
Total work due to both loads
$= \frac{1}{2} a_1 P_1^2 + \frac{1}{2} b_2 P_2^2 + b_1 P_1 P_2 + W \bar{y}$. (4)

Whichever of these two methods of loading is considered the final configuration of the structure will be the same, and the two expressions (3) and (4) will have the same value, therefore $b_1 P_1 P_2 = a_2 P_1 P_2$, from which it follows that $b_1 = a_2 = k$.

That is the deflection at B per unit load at A is equal to the deflection at A per unit load at B—a result which expresses the Maxwell theorem, though the writer has not been able to trace the reference.

Let P_2 at B = P with no load at A.

Then by equation (1)

$$y_A = a_2 P_2 = a_2 P = b_1 P = k P$$

and alternatively let

P_1 at A = P with no load at B

Then by equation (2)

$$y_B = b_1 P_1 = b_1 P = a_2 P = k P$$

which proves the first reciprocal relationship that P at A produces the same displacement at B that P at B would at A.

Solving the equations (1) and (2) for P_1 and P_2

we obtain

$$P_1 = \frac{y_A b_2 - y_B k}{a_1 b_2 - k^2} \text{ and } P_2 = \frac{y_B . a_1 - y_A . k}{a_1 b_2 - k^2}$$

Let P_1 be of such magnitude and direction that displacement at A is prevented, *i.e.*, make

$$y_A = 0 \text{ then}$$
$$P_1 = -\frac{y_B . k}{a_1 b_2 - k^2}$$

Next P_2 at B make $y_B = 0$ then

$$P_2 = -\frac{y_A k}{a_1 b_2 - k^2}$$

If y_A and y_B are equal, then P_1 equals P_2, proving the second reciprocal relationship.

magnitude with the length L, then the moment due to bending at any cross-section of the vertical column = P L when P is at A, and since

$$\frac{d^2 y}{d x^2} = \frac{P L}{E I_2} \qquad \frac{d y}{d x} = \frac{P L}{E I_2} x \qquad y = \frac{P L}{2 E I_2} x^2$$

—the constants of integration being zero.

When

$$x = h \text{ then } y_B = \frac{P L h^2}{2 E I_2} \quad . \quad . \quad (7)$$

the horizontal deflection at B.

When P acts horizontally at B the vertical drop at A equals the slope at B × L.

Thus considering bending only we have:

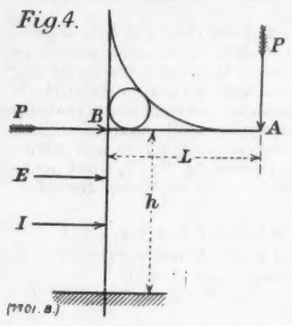
For the girder A B:

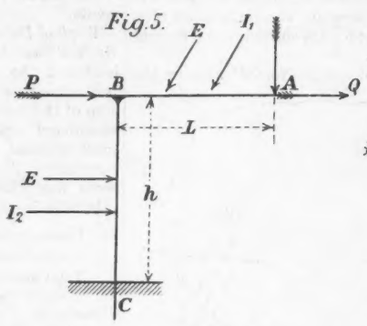
$$U_1 = \frac{1}{2 E I_1} \int_0^L P^2 x^2 \, d x \text{ and } \frac{\partial U_1}{\partial Q} = 0.$$

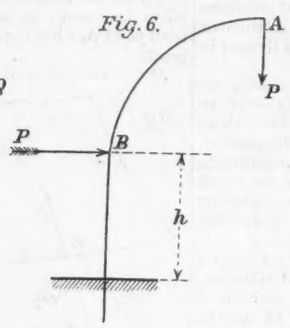
For the column B C:

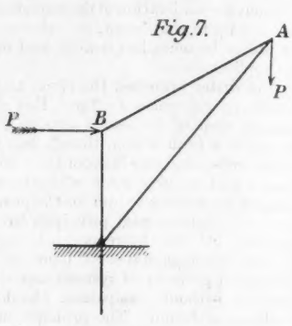
$$M_x = P L + Q (h - x) \quad \therefore \frac{\partial M_x}{\partial Q} = h - x$$

$$\frac{\partial U_2}{\partial Q} = \frac{1}{E I_2} \int_0^h \{P L + Q (h - x)\} \{h - x\} \, d x$$
$$= \frac{1}{E I_2} (\tfrac{1}{2} P L h^2 + \tfrac{1}{3} Q h^3).$$









To prove the third reciprocal relationship let displacement at B be prevented, then considering the equations

$$y_A = a_1 P_1 + k P_2 \text{ and } y_B = k P_1 + b_2 P_2$$

and writing $y_B = 0$ and $-P_2$ as the force at B when P_1 acts at A, we obtain

$$-\frac{P_2}{P_1} = \frac{k}{b_2} \quad . \quad . \quad . \quad (5)$$

Now consider P_1 removed with P_2 acting alone at B; then

$$y_A = k P_2. \qquad y_B = b_2 P_2.$$

and

$$\therefore \frac{y_A}{y_B} = \frac{k}{b_2} \quad . \quad . \quad . \quad (6)$$

equating (5) and (6).

$$-\frac{P_2}{P_1} = \frac{y_A}{y_B} \quad \text{Q.E.D.}$$

Verifications and Applications.—Having stated and proved these three relationships, it is worth while considering them in connection with certain practical examples in order to see how they agree with the usually accepted theory of flexure, as well as showing how unnecessary mathematical labour may be avoided in calculation.

Take, for example, the case where a member of an elastic structure supports a load, say, of 10 tons, at a certain point A, producing measured deflections at two other points B and C of 0·36 in. and 0·18 in. respectively. If loads of 6 tons and 12 tons are applied at B and C respectively, let it be required to find the deflection at A. The solution would be as follows:—

Ten tons at A produces 0·36 in. deflection at B and 0·18 in. at C.

∴ One ton at A produces 0·036 in. deflection at B and 0·018 in. at C.

Now by the first reciprocal relationship 1 ton at B produces 0·036 in. deflection at A.

∴ Six tons at B produces 0·036 in. × 6 = 0·216 in. deflection at A.

One ton at C produces 0·018 in. deflection at A.

∴ Twelve tons at C produces 0·018 in. × 12 deflection at A = 0·216 in.

∴ Total deflection at A = 0·216 + 0·216 = 0·432 in.

Referring to Figs. 4 to 7 by way of further illustration of this first reciprocal principle, though examples may be multiplied indefinitely, we may state that if a force or load acting vertically be applied at A it would produce a horizontal deflection at B equal to the vertical deflection produced at A by a force or load of the same magnitude acting horizontally at B.

Thus, for example, take the structure represented in Fig. 5 and consider the usual practical case where the horizontal deflection at B due to the flexure of the column is very small and not comparable in

The moment at distance x from fixed support C of vertical column = $P (h - x)$.

Then since

$$\frac{P (h - x)}{E I_2} = \frac{d^2 y}{d x^2}$$

we have

$$\frac{d y}{d x} = \frac{P}{E I_2} \left(h x - \frac{x^2}{2} \right)$$

and when $x = h$ we note that the slope at the top end B = the slope of part A B = $\frac{P h^2}{2 E I_2}$ from which by multiplying by L we obtain the vertical deflection at A

$$= y_A = \frac{P L h^2}{2 E I_2} \quad . \quad . \quad (8)$$

the same result as for the horizontal deflection produced equation (7), by the load P when applied vertically at A. These results are simple verifications of the first reciprocal relationship showing that it is consistent with the ordinary theory of flexure.

It is worth while considering the case of the structure represented in Fig. 5 from another point of view. Let U_1 and U_2 denote the work of flexure of A B and B C respectively, and let $U = U_1 + U_2$. Then by the Castigliano theorem:

$$\frac{d U}{d P} = y_A \text{ (P acting at A)}$$

$$\therefore \frac{d U}{d P} = \frac{d U_1}{d P} + \frac{d U_2}{d P}.$$

Considering first the girder A B, we have $M_x = P . x$, and since the work of flexure is given by

$$\frac{1}{2 E I_1} \int_0^L M_x^2 \, d x$$

we have

$$\frac{d U_1}{d P} = \frac{1}{2 E I_1} . \frac{d}{d P} \int_0^L P^2 x^2 \, d x = \tfrac{1}{3} \frac{P L^3}{E I_1}$$

= deflection at A due to flexure of girder only.

Taking next the part B C and noting that M = P L for any section, we have

$$\frac{d U_2}{d P} = \frac{1}{2 E I_2} . \frac{d}{d P} \int_0^h P^2 L^2 \, d x = \frac{P L^2 h}{E I_2}$$
$$= \frac{M h}{E I_2} \times L = \text{slope at B} \times L.$$

Hence

$$y_A = \frac{d U}{d P} = \frac{d}{d P} (U_1 + U_2) = \frac{P L^3}{3 E I_1} + \frac{P L^2 h}{E I_2}$$
$$= \frac{P L^2}{E} \left(\frac{L}{3 I_1} + \frac{h}{I_2} \right) =$$

Deflection at A due to flexure of girder + Deflection at A due to change of slope at B.

To find the horizontal deflection at A (or B) with P acting at A, assume a horizontal force Q acting at A at the same time, and, after finding an expression for the horizontal displacement y_B by the Castigliano theorem write Q = 0 in the result.

Now, making Q = 0, we obtain the final result:

$$\frac{\partial U}{\partial Q} = y_B = \frac{\partial U_1}{\partial Q} + \frac{\partial U_2}{\partial Q} = \frac{P L h^2}{2 E I_2}$$

the same result as before (equation (7)): *i.e.*, P acting at A produces the same horizontal displacement at B (or A) as that produced vertically at A by P acting horizontally at B.

(To be continued.)

THE GAS ENGINE POWER STATION OF PALMERS' SHIPBUILDING AND IRON COMPANY.

(Continued from page 198.)

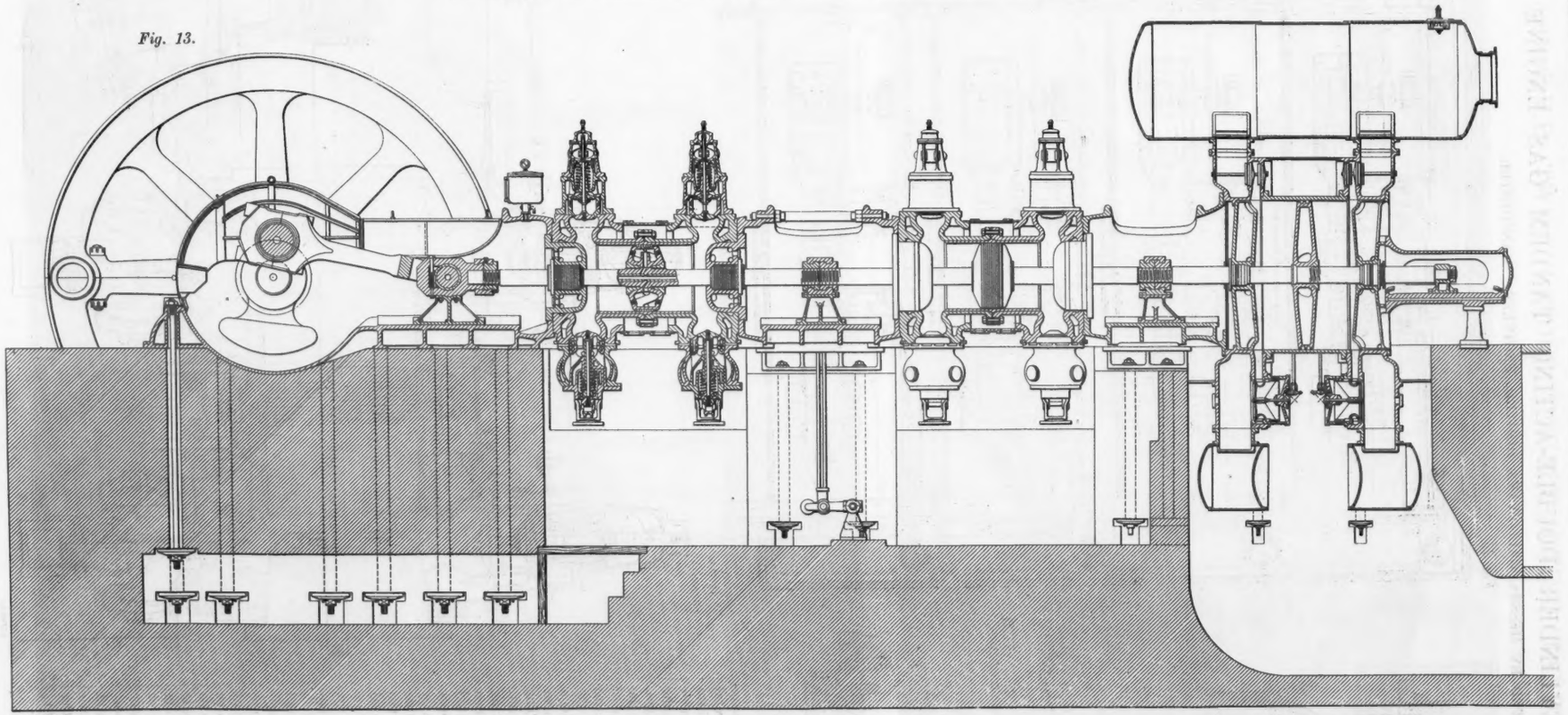
As already indicated the gas engine plant comprises eight vertical tandem engines built by the National Gas Engine Company, and driving electric generators and four horizontal gas blowing engines built by Messrs. Galloways, Limited, of Manchester. As the duty of the blowing engines is directly concerned with the operation of the blast furnaces we may deal with them before passing to the electric plant. The blowing engines are of the horizontal double-acting type with two gas cylinders and one double-acting blowing cylinder. They are each of 1,650 h.p., run at 85 r.p.m., and can deliver 35,000 cub. ft. of free air per minute up to a pressure of 11 lb. per square inch, or a decreased volume up to 15 lb. per square inch. The gas, as indicated in connection with our description of the cleaning plant, is very clean and quite free from tar, and when engine pistons have been withdrawn after six months' running they have been found to be as clean as when put in. In the early days of the plant considerable attention was paid to the question of overhaul and to examination of internal parts, and it was decided to overhaul the engines twice a year, but after several such inspections it was decided that it was quite unnecessary to attend to the engines in this way more often than once in twelve months.

The two cylinders of the engines are arranged in tandem and work on one crank. The engines operate on a four-stroke cycle, and as each cylinder is double-acting there is an impulse each stroke as in a double-acting steam engine. The cylinders are 1,150 mm. in diameter, the stroke being 1,300 mm. The arrangement of the four engines in the power-house is shown in Fig. 15, on page 290, while a longitudinal section of one of the engines is given in Fig. 13, on page 289. Various parts are detailed in Figs. 14, 16 and 17, on page 290, and two general views of the blowing engine end of the power-house are given in Figs. 18 and 19, on page 291. The gas engine driven electric plant can be seen in the background of this latter figure. As will be seen the engine-house is a well-lighted building of modern

1,650-B.H.P. TWO-CYLINDER DOUBLE-ACTING TANDEM GAS ENGINE.

CONSTRUCTED BY MESSRS. GALLOWAYS, LIMITED, ENGINEERS, MANCHESTER.

Fig. 13.



(7756.B)

type and the whole installation presents a very fine appearance.

One of the main features of interest in a large gas engine is the arrangement of the cylinders and framing in order that trouble may not be experienced owing to the large temperature differences which have to be allowed for, and these latest pattern Galloway engines are of much interest from this point of view. The principal fixed members of the engine are the main frame, which carries the crankshaft bearings, the front gas cylinder, the front distance-piece which carries the front cross-head slide, the rear gas cylinder, the rear distance piece, and the blowing cylinder. There is also a back-end member carrying the slide for the tail rod. These various parts are well shown in the longitudinal section of the engine given in Fig. 13. Of these the only one bolted direct to the foundations is the main frame carrying the crankshaft bearings. Each of the two distance pieces and the blowing cylinder sits on and is free to slide on machined sub-bases which are bolted to the foundations. The tail rod support is also free to adjust itself on its column. The engine cylinders are carried only from their ends by the main frame and distance pieces and are not directly connected to the foundations in any way. This arrangement gives the whole fixed structure great adaptability, and allows it to adjust itself to the conditions induced by the local high temperatures of operation, so that when working the engine is quite free from any expansion stresses.

The main frame is of cast-iron in a single piece with a solid bottom which forms an oil tray and prevents oil from getting on to the foundations. The frame rests on the concrete bed throughout its entire length. Its cheeks are in the form of box girders and are made high, so that the crankshaft bearings are accommodated entirely in their depth and the thrust is taken directly by the frame. As will be seen from Fig. 13, the frame has only one slide surface, the upper portion of the frame being open to allow of easy access to the crosshead and cylinder. This slide surface is arranged low down so that the cylinder cover and pistons may be easily withdrawn. The distance pieces between the two cylinders and between the rear engine cylinder and the blowing cylinder are similarly arranged, open at the top for convenience of access to the cylinders and with single slide surfaces at such a level that the cylinder covers may be easily taken off and the pistons withdrawn. A connecting stay which is shown in position in Fig. 13, and can be seen in the general view given in Fig. 18, is arranged across the open top of the middle distance piece. This serves to stiffen the member, and may be easily removed when access to the interior of the distance piece is required. The cylinders are formed with spigots which fit into circular recesses formed in the ends of the main frame and distance pieces, and the slides are bored at the same setting in the boring machine as these recesses, so that concentricity of the whole structure is ensured.

The method adopted for the construction of the cylinders is of considerable interest. In place of a single casting, which with its water jackets is somewhat complicated and difficult to obtain sound throughout, the cylinder is made in halves, bolted together at the centre of the barrel as can be seen in Fig. 13. One of the incidental advantages of this arrangement is that really sound metal is ensured around the valve ports. With a single-piece cylinder cast vertically the metal can hardly be uniform at the upper and lower ends, but with the two-part cylinder each half is cast with the valve ports at the bottom and with a large runner above the central flange, so that the best condition for

1,650-B.H.P. TWO-CYLINDER DOUBLE-ACTING TANDEM GAS ENGINE.

CONSTRUCTED BY MESSRS. GALLOWAYS, LIMITED, ENGINEERS, MANCHESTER.

Fig. 14.

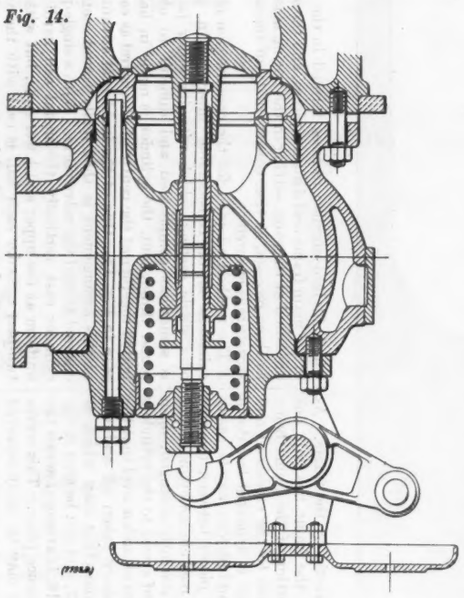


Fig. 15.

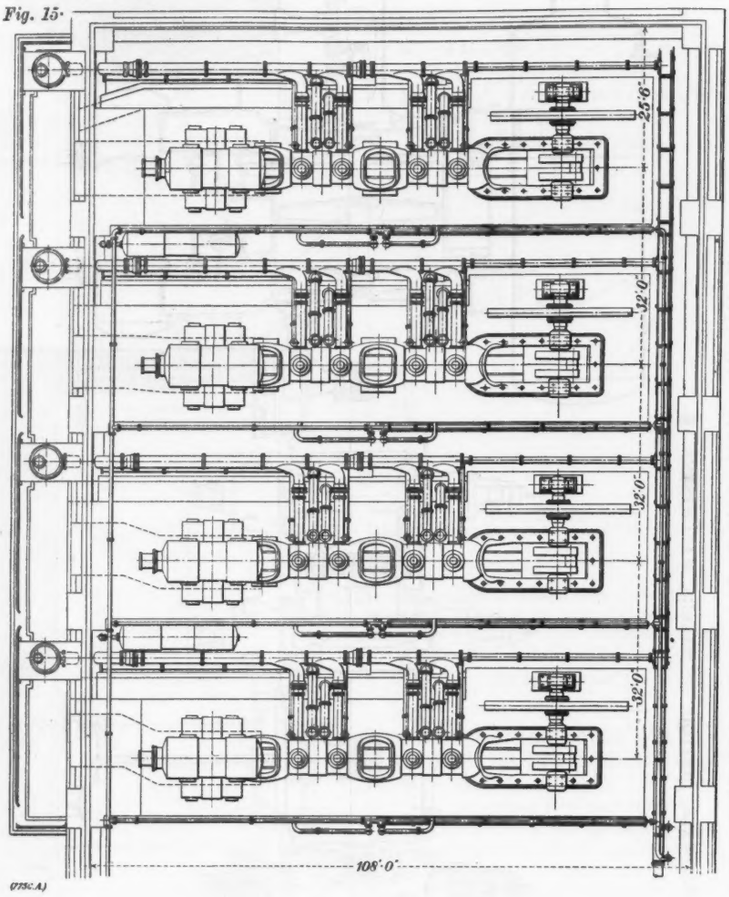
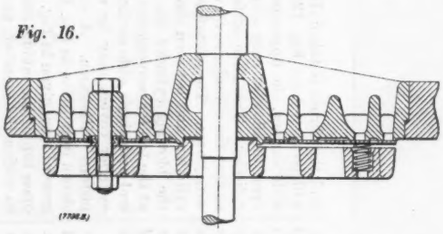


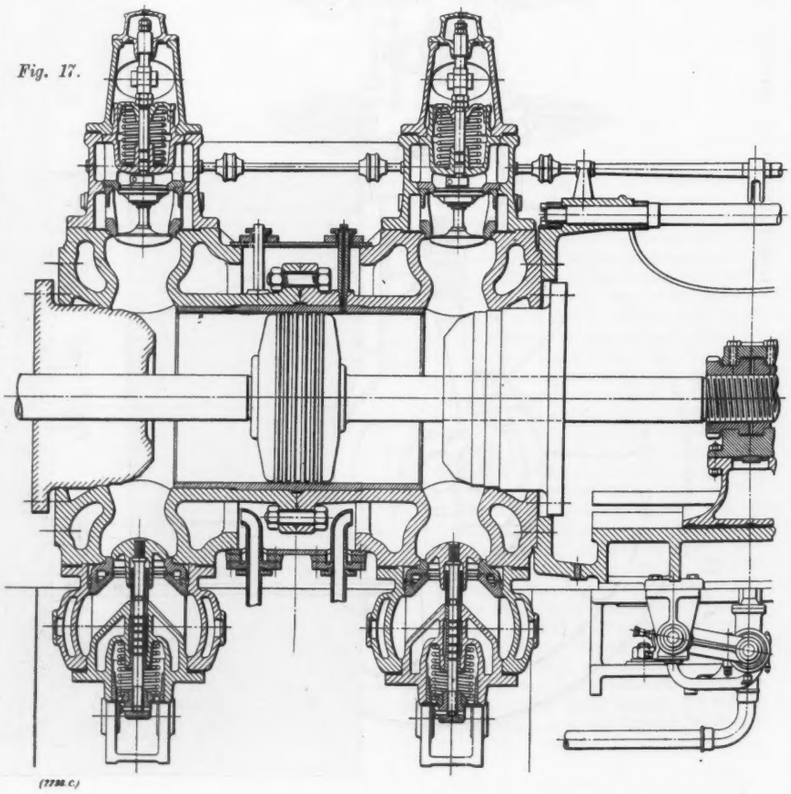
Fig. 16.



soundness in the valve ports is ensured. The two-part cylinder is fitted with a liner of hard metal which is formed with a central collar which fits into grooves turned in the two half bodies. The cylinder barrels are strengthened at the point where the grooves are turned by the heavy connecting flanges, while the arrangement absolutely ensures that the liner cannot move. A further interesting feature of this built-up cylinder is that no attempt is made to cast a complete jacket. The centre parts of the half barrels are open, and the jacket is formed by a mild steel plate made in halves which fits over machined facings on the cylinder castings. The connection is made watertight with a rubber joint. This arrangement (see Fig. 17) eliminates the casting stresses and stresses due to unequal expansion when working which may be present if a complicated single cast cylinder is used, and also makes proper inspection and cleaning of all parts of the water space possible by removing the jacket. Cleaning holes are also provided in the jacket to enable the water spaces to be washed out without the removal of the jacket.

The pistons are hollow and water-cooled, and are stiffened with internal diagonal ribs which prevent distortion. Self-springing cast-iron rings are used. The pistons are coned on each side of the boss, and are secured to the rods by coned nuts. The arrangement, which can be seen in Fig. 13, permits longitudinal adjustment of each piston on its rod so that the rings may be made to work exactly edge to edge with the ends of the cylinder liner. The piston rods are water cooled, the water connection being made through rocking pipes connected to the coupling between the front and back rods. Concentric water passages are formed through the rods, and the water service passes from the rocking pipes down the rods, through the pistons and back again. The piston-rod coupling is made of cast-steel in the form of two half-nuts which are bolted together over the screwed ends of the rods, the lower half coupling

Fig. 17.



1,650-B.H.P. TWO-CYLINDER DOUBLE-ACTING TANDEM GAS ENGINES.

CONSTRUCTED BY MESSRS. GALLOWAYS, LIMITED, ENGINEERS, MANCHESTER.

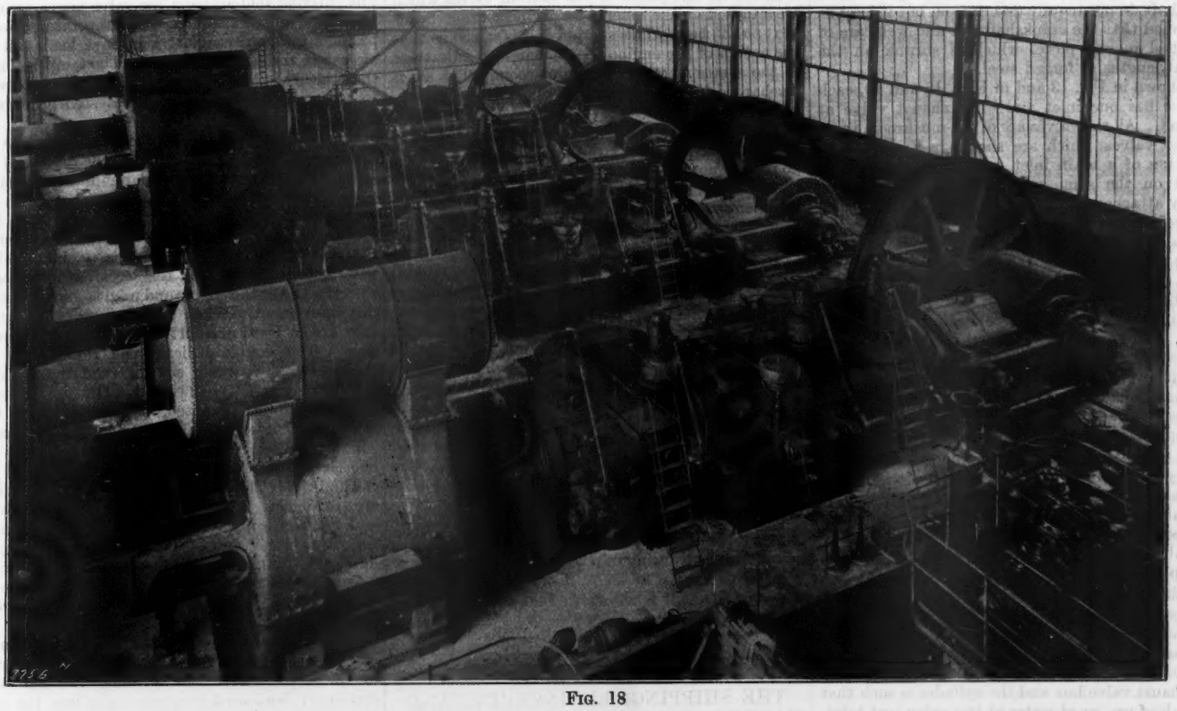


FIG. 18

FIG. 19.

being bolted to a slipper which runs on the slide carried by the distance piece. The main crosshead is of mild steel, the connecting rod pin bearings being of phosphor bronze, white metal lined, with wedge and screw adjustment. The connecting rod and crankshaft do not require description, but it may be mentioned that the crankshaft pin and webs are of cast steel in one piece, which is shrunk on the straight lengths of forged steel.

As shown in Fig. 13 and in Figs. 18 and 19, each cylinder has one inlet and one exhaust valve at each end. All the valves are of the mushroom type, the inlet valves, which are shown in Fig. 17, each consisting of a main inlet valve and a gas valve carried on the same spindle. The gas valve is flexibly attached to the spindle in such a way that both valves can close even if the seatings become unequally worn, so that back-firing and waste of gas are prevented. The exhaust valve is also shown in Fig. 17 and to a larger scale in Fig. 14. This latter figure shows a section at right-angles to that given in Fig. 17. The valve itself is not water-cooled, as experience has shown that with a properly cooled seat and casing entirely satisfactory operation is obtained with a non-cooled valve, and the arrangement has the advantage of eliminating some rather troublesome water connections. The exhaust valve box and seating are of a patented design and comprise a separate outer casing, an inner casing and a valve seat, all of which are water cooled. The various water passages can be seen in Figs. 13 and 17. The valve seat itself is in the form of an inverted U-shaped ring made of hard cast-iron, and is easily renewable. The joint between the valve seat and the top of the inner casing is in the form of two concentric spigoted circular rings and is made tight by a copper ring joint. The whole arrangement ensures efficient water cooling of all parts and ease of access for inspection and cleaning of the water spaces. The arrangement of the joint between the exhaust valve box and the cylinder is such that any leak of gas, or of water at the valve seat joint, may easily be seen. This is of importance, as an unchecked leak might lead to cracking of the cylinder.

The valves are operated from a camshaft carried along the side of the engine and driven from the crankshaft through a layshaft and machine-cut gear running in oil baths. The camshaft and layshaft with the gear boxes can be seen in Fig. 18. The valves are operated by rods actuated by the cams, and a single cam only is used for each pair of admission and exhaust valves, so that four cams only are required for the two cylinders. The cams are made of forged steel with hardened faces, and their operation is not affected in any way by longitudinal expansion of the engine. Governing is carried out entirely by throttling, throttle valves being placed in both the air and gas passages immediately before the valve boxes. The gas throttle valves for all cylinder ends are mounted on one spindle, and the air throttle valve spindles are connected to them so that all move simultaneously. The interlinkage is such that at light loads the gas is throttled more than the air, so that the quality as well as the quantity of the charge is modified. The supply of gas and air takes place during the whole of the suction stroke, and a thorough mixing is consequently obtained which is favourable to complete combustion of the charge at the commencement of the power stroke. A handwheel control is provided in connection with the throttled valves so that the engines may be run at varying speeds depending on the blast requirements of the furnaces. Ignition is by low-tension current at 65 volts to 70 volts. A distributing commutator at the end of the camshaft completes a circuit through a solenoid at the appropriate moment. The plunger of the solenoid, which is thus drawn in, moves a lever attached to the moving spindle of the ignition plug and so breaks circuit at the sparking points. The moment of ignition and the duration of contact of the brushes on the commutator brushes are capable of adjustment. The engine is provided with electrically-driven barring gear and arranged for compressed air starting.

The air cylinder of the blowing engine consists of a simple cylindrical barrel spigoted into the air heads which carry the suction and delivery valves. The arrangement is clearly shown in Fig. 13. The air heads are cast in halves and a large air belt is formed round the cylinder barrel by means of a cylindrical steel jacket fitted between them. Air enters the air belt from a suction chamber in the foundations and passes to the suction valves which are situated on the inner sides of the suction heads next to the belt. This suction belt is sealed so that the action of the engine does not induce pulsations in the atmosphere of the engine-room. The air is discharged from the blowing cylinder into an overhead receiver, clearly shown in Figs. 13, 18 and 19, whence it passes steadily to the blast main. When it is necessary to supply the blast furnaces with air above the normal pressure of 11 lb. per square inch, two cylindrical vessels situated below the blowing cylinder are put in communication with the cylinder ends. These vessels, which can clearly be seen in Fig. 13, add to the clearance volume so that less air is drawn in at each suction stroke and the reduced quantity of air can be compressed to the higher pressure without any increase in the power of the engine. The same valves which control the extra clearance vessels are also used to put the cylinders to atmosphere to relieve the load when starting, or when it is desired to stop the blast temporarily without stopping the engine. These valves are shown in Fig. 13. The suction and delivery valves are of Galloway's patented type and consist of steel discs formed with concentric annular slots. The valve is provided with three annular segments which act as light springs and suspend the valve between the cast-iron valve seat and the valve guard, both of which are multiple-ported. Small spiral springs working in recesses in the valve guard bear on the valve and ensure its efficient seating. The arrangement is shown in Fig. 16.

(To be continued.)

THE SHIPPING, ENGINEERING AND MACHINERY EXHIBITION AT OLYMPIA.

(Continued from page 265.)

ON the stand of Messrs. Gleniffer Motors, Limited, of Anniesland, Glasgow, there is a representative display of paraffin and petrol engines for motor boat propulsion. This firm have standardised their manufactures in two series, of which the first has cylinders of 6 in. bore and 8 in. stroke, while the other, a recent introduction, has dimensions of 4½ in. diam. and 5 in. stroke.

The engine illustrated in Figs. 35 to 39, Plate XIX, is one of the latter type of 24/28 h.p. It is a four cylinder set with the cylinders cast in pairs and works on the four-stroke cycle. The cylinder heads are detachable and screw-down priming cocks are fitted to the top of each. The valves are of the simple mushroom type with nickel steel spindles and cast-iron heads. Renewable cast-iron guides are pressed into place in the cylinder casting for the accommodation of the spindles. They are set at an angle of 35 deg. to the cylinder axis. Rocking bell-crank levers convey the motion from the cam shaft to the valves. These are provided with rollers on the cam end and with hardened screws at the valve end and are enclosed behind easily detachable covers. The main bearings of the engine and reverse gear are of die cast white metal and are all mounted within the lower half of the crank case. They are interchangeable with those of the connecting rod big ends. Machine-cut wheels constitute the timing gear and are enclosed in the forward end of the crank case by a separate cover. The governor is mounted on a frame which is bolted to the camshaft wheel and operates a sliding sleeve on an extension of the cam shaft. A small lever takes its motion from a horseshoe washer in a groove on this sleeve and communicates it through a spindle and coupling rod to the throttle.

The vapouriser used for the paraffin type of engine has the unusual feature that the throttle controls the main air inlet. Part of the air passes through a heater tube, after which it ascends through the choke tube, drawing with it the fuel from the jet and continues through the long vapouriser tube to the engine inlet. An automatic spring-held air valve is provided and has an oil dash-pot below and secured to it to prevent violent movements. When running on full load only a little of the entering air passes through the heater tube and a very rich mixture is consequently present in the vapouriser tube, which is also heated by the engine exhaust. The entering cold air from the valve mixes with the fuel vapour and reduces its temperature before passage into the engine. On low loads all the air passes through the heater. The temperature of the mixture is then lower than formerly, but owing to the partial vacuum in the system the oil is completely vapourised.

The reverse gear is incorporated within the flywheel at the after end of the engine. It is of the bevel gear epicyclic type and put into and out of action by the motion of a sector whose arm has at its end a semi-circular sleeve which fits in a groove on the operating casing. A hand wheel, on the spindle of which there is a pinion, whose teeth gear with those on the sector, is mounted at the after end of the engine and used to give the necessary movement. When reducing gears are fitted, they are enclosed in a further extension of the main base. The double helical type running in ball bearings is the system adopted and the standard ratio of reduction is 2½ to 1. On the stand of Gleniffer Motors, Limited, a similar set to that illustrated, fitted with glass inspection doors, is run by an electric motor to demonstrate the effectiveness of the lubrication system.

The British Thomson-Houston Company, Limited, are exhibiting a typical range of the lighting and ignition apparatus manufactured by them at their Coventry works. The magnetos for engines having 1, 2, 3, 4 or 6 cylinders, are of the usual rotating armature type, but in the case of magnetos for the more powerful marine engines with 8, 9, 12 or 14 cylinders the windings are stationary and the rotor is completely devoid of wire. Magnetos of this kind, which are known as the "Polar inductor type," have the windings carried on a stationary laminated iron core built into the main body of the machine, so that a thoroughly strong and durable construction is obtained both from the electrical and the mechanical point of view. Longitudinal and cross sections through a magneto of this type are reproduced in Figs. 40 and 41 on Plate XIX. The four salient pole-pieces of the rotor are magnetised in an alternate sense by the permanent steel magnets which surround the machine. The passage of these pole-pieces past the core which carries the windings causes reversals of the magnetic flux through the core, and consequently the generation of a voltage in the coil. The flux reversals cause four sparks per revolution of the rotor. The primary winding is short-circuited, and is interrupted at suitable moments by the action of the contact-breaker, thus producing a high tension spark at the plug, which is, of course, connected to the secondary winding. In addition to magnetos the British Thomson-Houston Company are showing car-lighting generators of the permanent magnet type which are supplied either as separate units or combined with magnetos.

The Degory No-jet Carburator Company, of 93, Moore-park-road, Fulham, London, S.W.6, are showing a number of carburettors ranging from the smallest motor cycle size to what is claimed to be the largest carburettor yet made. The action of the Degory carburettor will be understood from the section on Plate XIX, Fig. 42. The petrol enters the float chamber through a needle-valve controlled by the float in the ordinary way. The main supply passes thence through the left-hand jet, and so to an annular passage surrounding the choke-tube. Radial holes connect this passage with the throat of the tube, so that the incoming air picks up the petrol at numerous points where the velocity of the air is highest and its pressure least. When the butterfly throttle is nearly closed and the engine therefore running slowly, the carburation of the air is effected by the right-hand jet, the fuel passing to the engine through an outlet opposite the throttle valve, the slight opening of which causes the fast moving air to pick up and vapourise the petrol. In the larger carburettors a multiple choke tube is employed, seven or more throats being provided in parallel and the petrol led to each in a manner similar to that shown in the illustration we publish. The very large carburettor to which we referred above has an air pipe of 4 11/16-in. bore, and there are

no less than 37 choke tubes in parallel, each with 12 petrol holes, so that the fuel is brought into contact with the air at 444 points. This carburettor is designed to work with an engine having a cylinder bore of 24 in. and a stroke of 30 in. The Degory carburettor is stated to be extremely efficient and to respond at once to any variation in power required of the engine. It is claimed to vapourise paraffin fuel without the use of heated air or any separate vapouriser, so that it is useful for the large number of marine and stationary engines which use paraffin as fuel.

The Victaulic Company, Limited, of 28, Victoria Street, London, are showing various lengths of pipe coupled together with their special jointing arrangement in order to demonstrate the flexibility of the joint and its tightness under pressure. The joint, which we have previously illustrated, consists of an elastic ring of C section, which acts like a double cup-leather. The ends of the pipes to be coupled are pushed into the ring, which is then protected by an iron guard ring made in halves and engaging with shoulders on the pipes, so as to give longitudinal strength to the joint. On the stand is a sample Victaulic joint as used by the Metropolitan Water Board on a 36-in. water main from Westminster Bridge to Tooley-street, working at a pressure of 130 lb. per square inch. It may be mentioned that in Glasgow the system is being used on 24-in. gas mains, and that the London & Pacific Petroleum Company have now about 40 miles of oil pipe, from 10 in. diam. downwards, jointed in the manner described. There are also more than 50 miles of compressed air mains in the North of England mining districts in which the Victaulic method of jointing is used.

Messrs. Lacy, Hulbert and Co., Limited, of Beddington, Croydon, Surrey, are exhibiting several examples of small air-compressors for various purposes. Figs. 43 to 46 on Plate XIX illustrate a portable petrol-driven air-compressor constructed by Messrs. Lacy, Hulbert and Co., Limited for steel construction, road-breaking and contractors' work generally. The makers were the pioneers of portable air-compressing plant in this country, and the machine illustrated represents the outcome of a long experience in the design of such plants. The framing and wheels are of steel and the front axle is arranged to swivel about its centre. The compressor which, as will be shown by Fig. 43, is situated between the radiator and the air receiver, has a capacity of 50 cu. ft. of free air per minute compressed to 120 lb. per square inch. It works on the principle explained below in connection with Fig. 48, and is fitted with ball or roller bearings throughout. It runs at 1,000 r.p.m., being directly coupled to a 20-b.h.p. Dorman engine, shown at the front of the carriage in Fig. 46. As the power required to drive the compressor at full load is only 14 b.h.p. it will be seen that an ample margin has been provided. The cooling water circuits for the engine and the compressor are kept distinct, so that the compressor may be efficiently cooled while the engine works at a comfortable temperature. The weight of the plant complete with petrol tank, silencers, automatic unloading valve and all tools, is only 21 cwt., and the overall dimensions are shown in Figs. 43 and 44. Such a plant will drive three or four riveting or chipping hammers, or, alternatively, a couple of road-breakers. Several engaged on the latter work are to be seen in the streets of London.

A further exhibit of Messrs. Lacy, Hulbert and Co., Limited, which deserves notice is the electric air-blast apparatus shown in Fig. 47, Plate XIX. This consists of a small rotary blower of the sliding abutment type mounted on top of an electric motor of 1 h.p., by which it is chain-driven. The purpose of the machine is to blow dust out of dynamos, motors and electrical apparatus generally. It gives a very powerful blast of air which can be directed on to its work by means of six feet of flexible hose provided with an insulated nozzle. The standard machine to give a supply of 110 volts D.C. or 220 volts D.C., weighs only 74 lb. net, and being fitted with a handle for carrying, it is essentially portable. Motors for higher voltages or for single or three-phase current can be fitted if desired.

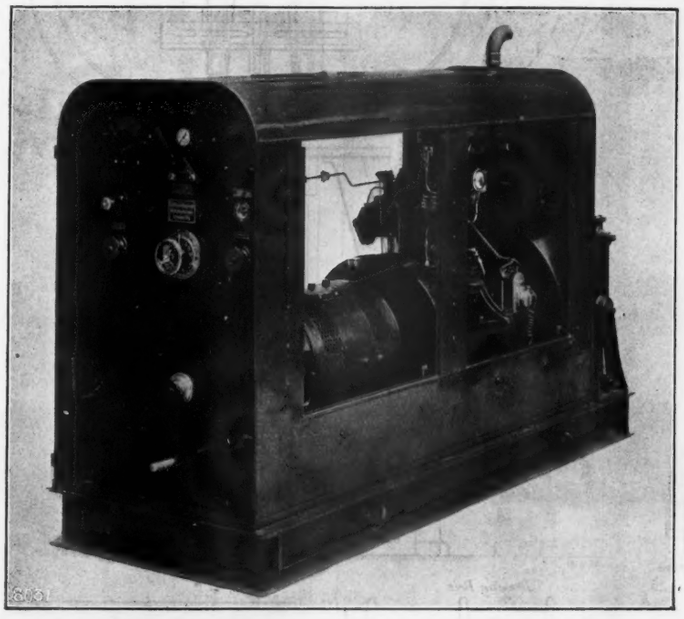


FIG. 49. ELECTRIC WELDING PLANT; MESSRS. ALLOY WELDING PROCESSES, LIMITED, LONDON.

In Fig. 48, Plate XIX, we illustrate another of the sets on the stand, namely, a motor-driven compressor capable of delivering 12 cu. ft. of free air per minute at a pressure of 100 lb. per square inch. The speed of the motor is 1,200 r.p.m. The bearings throughout the compressor are of the ball or roller type, but the particular feature of the machine and the reason why an extremely high volumetric efficiency can be obtained at so high a speed is to be found in the design of the cylinder. The latter has a series of ports at its lower end which communicate with the crank-case. As the piston descends it draws air into the cylinder in the ordinary way through an inlet valve at the top, and it also slightly raises the pressure of the air in the closed crank-case. At the bottom of its stroke the ports are uncovered by the piston, and the compressed air in the crank-case rushes through them into the cylinder, giving a "super-charging" effect. Machines of this type are built with a capacity ranging from 0·6 cu. ft. to 140 cu. ft. of free air per minute, and for working pressures up to 200 lb. per square inch.

The Welin Davit and Engineering Company Limited, of 3, Lloyd's-avenue, London, have, in addition to examples of their well-known davit gear, two very interesting exhibits on their stand. The first of these is the "Arca" regulator which may be used for controlling temperature pressure, voltage, quantity of flow, or, indeed, any condition which is capable of being regulated at all. We illustrated and described the apparatus very fully in our issue of February 9 last, page 167, so that we need not now do more than remind our readers of the principle on which it works. Any variation of the pressure, temperature or whatever is to be controlled is arranged to alter the position of equilibrium of a delicately balanced lever, one end of which is being played upon by a small jet of water issuing from a nozzle. Any motion of the lever towards the nozzle, for example, restricts the flow from the jet and causes a slight rise of pressure in the water supply pipe. This pipe is connected to a diaphragm-chamber, and the rise of pressure causes the diaphragm to move and to alter the position of a piston valve which controls the admission of the pressure water to a hydraulic cylinder. The actual work of operating a valve, moving a rheostat, or whatever has to be done, is performed by the hydraulic cylinder, any required power being, of course, readily obtainable. The thoroughly mechanical design of the apparatus, its extreme sensitiveness, and its freedom from delicate electrical contacts render it very attractive.

Another exhibit of the Welin Davit and Engineering Company Limited is the "Mox Briquette," which is a small sheet-iron capsule containing a mixture of finely divided aluminium and iron oxide, which when ignited produces extremely rapid and intense heat. A pair of crossed slots are punched through one side of the capsule and through them is visible a covering of waterproof paper. To ignite the capsule a special match is pushed through the paper at the centre of the cross, penetrating into some powdered material which acts as a starter for the surrounding mixture. The projecting portion of the match is then ignited by being rubbed on a box and the contents of the capsule are immediately raised to a high state of incandescence. There are many uses for the briquettes, such as the heating of soldering irons, the rapid production of hot water, &c., but one important use is likely to be in connection with the starting of hot-bulb oil engines. For this purpose a briquette is placed in a copper container, the stem of which projects through the cylinder head into the combustion space, and is then ignited. Within 10 or 15 seconds the copper stem is hot enough to ignite the charge and the engine can be at once started. Nothing has to be unscrewed or screwed up again to hold the briquette, which merely lies in its copper pan, and is covered by a light lid when burning. No smoke or dangerous fumes are given off by the chemical action which takes place. It is impossible to ignite or explode the briquettes without the deliberate use of the special match provided. They can be put in an ordinary fire for an indefinite period without anything happening, and even in a blacksmith's forge they will not burn until the heat is sufficient to melt their iron capsules.

Among the exhibits of electric welding equipment and accessories shown by Messrs. Alloy Welding Processes, Limited, of Church-street, Islington, London, there is a self-contained engine generator set of compact and well arranged design. It is a direct-current plant of the type giving the electricity requirements at the starting of the arc and also during its burning down in quite an automatic way. As it is necessary to have a fairly high voltage to strike the arc and a comparatively low one to pass the required current through it once it is started, the generator is designed to have a markedly drooping characteristic. This is achieved by having some of the field coils acting against the others, and only energised when current is passing in the welding circuit. A great deal of success has been attained in the design of this type of generator, which is made to be self-stabilising, and its use has proved very serviceable in welding work where each operator has

ELECTRIC COIL-FORMING MACHINE AT THE OLYMPIA EXHIBITION.

CONSTRUCTED BY THE MIDLAND DYNAMO AND MOTOR REPAIRS COMPANY, LIMITED, LEICESTER.

Fig. 50.

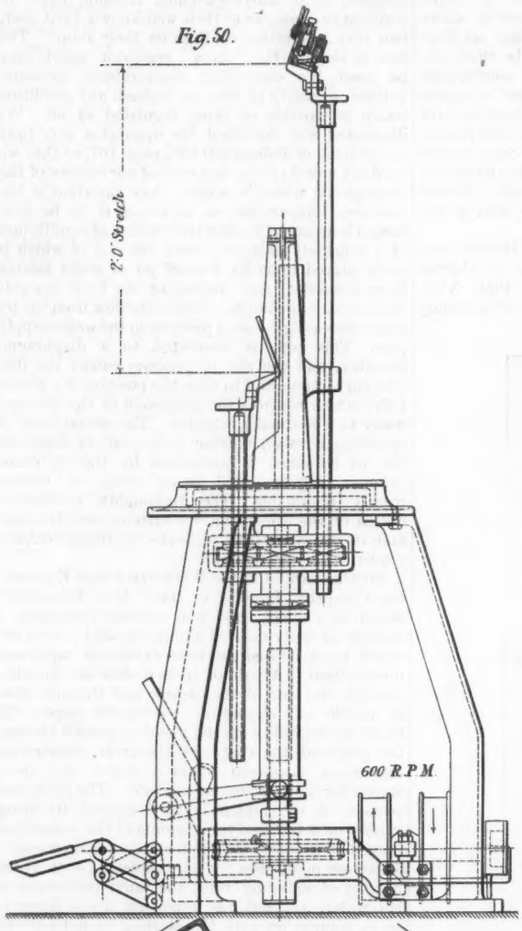


Fig. 51.

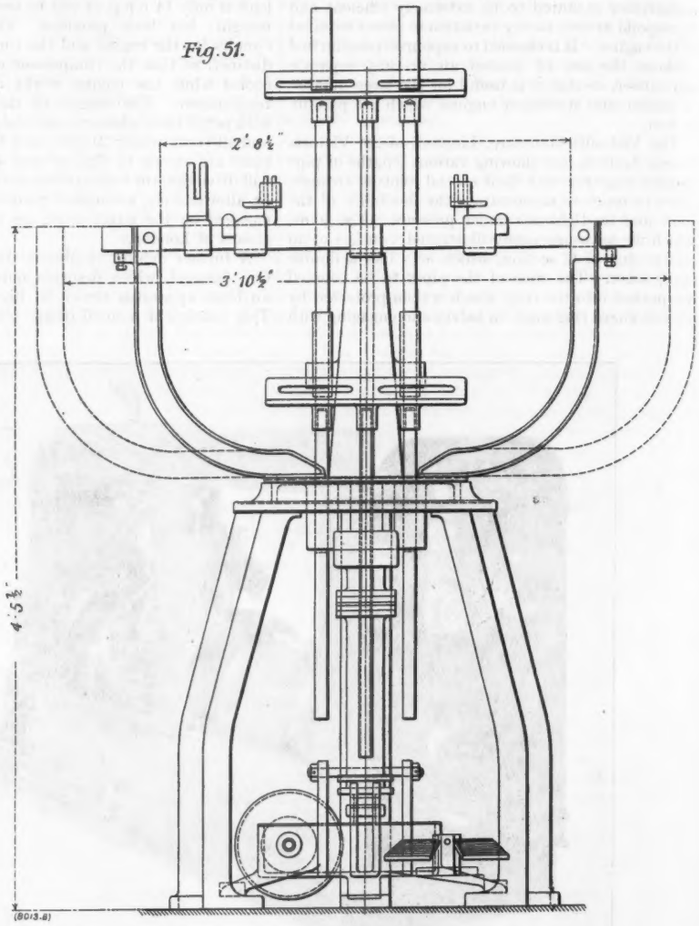


Fig. 52.

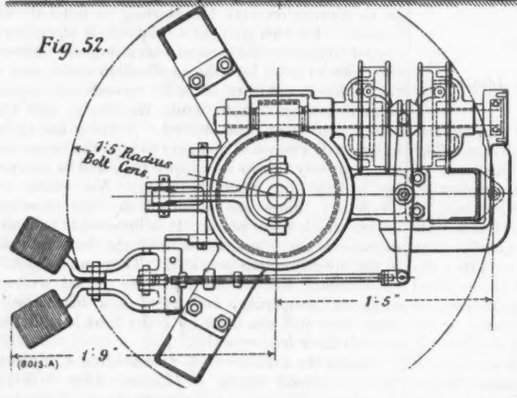


Fig. 53.

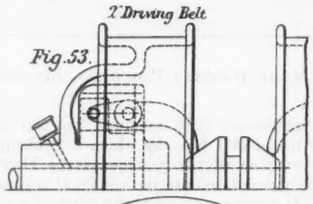
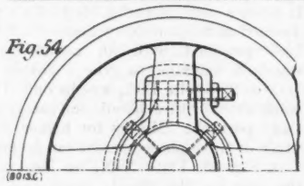


Fig. 54.



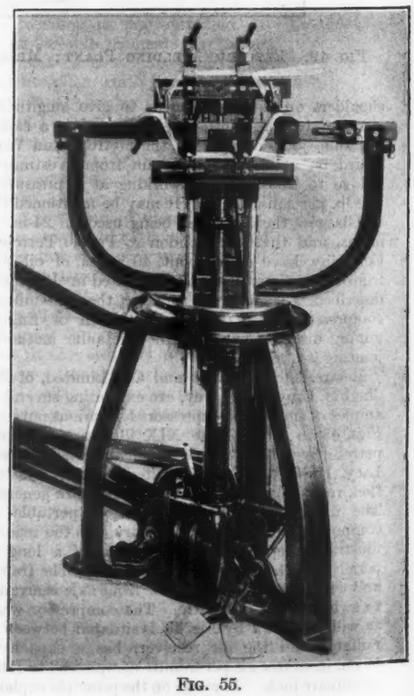


FIG. 55.

a separate generator set, as is commonly the case in outside repair work. The great waste when large currents are controlled by the use of resistances is entirely obviated when a dynamo of this type is used.

The power unit in this standardised plant, shown in Fig. 49, page 293, is a petrol engine of 10 h.p. constructed by Messrs. L. Gardner and Sons, Ltd., of Patricroft, Manchester. Beside the engine, which is erected on a welded steel frame base, are the petrol tank, radiator and fan. The 6-kw. generator is directly coupled to the engine, and has the drooping characteristic already referred to. At the end of the casing surrounding the plant, there is a control panel of steel plate on which the instruments, switch and shunt regulator are mounted, and through which the starting handle shaft passes. The shunt regulator can be set to the position suitable for the supply of the current requirements of any size of electrode, ranging from 50 to 200 amperes. The ammeter, voltmeter and gauge for the oil pressure are situated above the regulator and the magneto switch and throttle control lever to each side. The handle of the single pole switch for the welding circuit is on the same panel as well as two Simmonds watertight plugs for the welding connections. The switch and shunt regulator are erected on the back of the control board. Steel plate doors are provided to close up the whole plant when it must be left on the site of a repair job, and there are receptacles inside the casing for tools, spares and electrodes.

A.W.P. electrodes, the standard product of this

firm, are shown in use on the stand. They are supplied to suit the requirements of welding work on the various types of iron and steel and some of the non-ferrous metals. Their use has been approved for ship construction and repairs by Lloyd's Register, the British Corporation and the Bureau Veritas, after passing the prescribed tests.

The Midland Dynamo and Motor Repairs Company, Limited, of 64, Belgrave-gate, Leicester, are showing a new machine called the "Quickway" coil-forming machine, by means of which a boy or girl can make armature and stator coils of any ordinary size with ease and accuracy. The machine is illustrated in Figs. 50 to 55 on page 294. The drawings are a little difficult to follow in detail but the general method of operation can be understood. The pulleys at the base of the machine are driven in opposite directions by means of open and crossed belts. According as one or other of the pedals is depressed by the foot of the operator, the corresponding pulley is caused to drive the worm shaft, and the central spindle is revolved in one or other direction by the worm gear shown. To the upper end of this spindle is fixed a spur wheel gearing with two pinions as shown in Fig. 50. Each pinion acts as a nut for a vertical screw, which carries at its upper end a cross head on which a pair of adjustable clips are fitted. The screws are respectively right and left-handed, so that they move in opposite directions from the "full-stretch" position shown in Figs. 50, 51 and 55 until they are opposite each other at the same level. When they are in the latter position the wire to be wound is temporarily clipped in a vice, which is indicated near the left-hand end of the horizontal bar in Fig. 51. Before coming to the vice the wire is passed through a frictional straining clamp which keeps it taut during the winding process. Referring now to Fig. 50, a long sleeve will be seen surrounding the centre spindle and moveable vertically by a lever and fork arrangement. The sleeve is splined to the spindle, so that it rotates with it. The wire having been clipped in the manner described, the operator raises the sleeve which then engages by means of a dog-clutch casting carrying the pinions. The whole of the upper part of the machine then revolves, winding the wire in the form of a very elongated coil round the end-stops on the horizontal bar and the other adjustable clips on the stretching heads. The clips are inclined as shown in Fig. 50, so that the wire is laid at an angle to suit the radial divergence of the armature slots into which it is required to be placed. After one turn has been wound the vice is moved out of the way, and the rotation of the machine continued till the requisite number of turns are wound. The clips are then tightened so as to maintain the rectangular section of the coil. Before the machine is re-started the dog-clutch is disengaged. The depression of the pedal then causes the rotation of the gear only, with the result that the cross-heads are moved apart, stretching the coil into the familiar hexagonal shown in Fig. 55. Each coil leaves the machine completely formed and ready for taping. There is no practical limit to the size of coil which can be wound, and specially shaped coils can be made by suitable attachments. The machine is easy to set up for any particular size of coil, and as many as thirty complete and absolutely interchangeable coils may be made per hour by an experienced operator. Machines of this type are in use in Portsmouth Dockyard, the shops of the South African Railways, and many other important works.

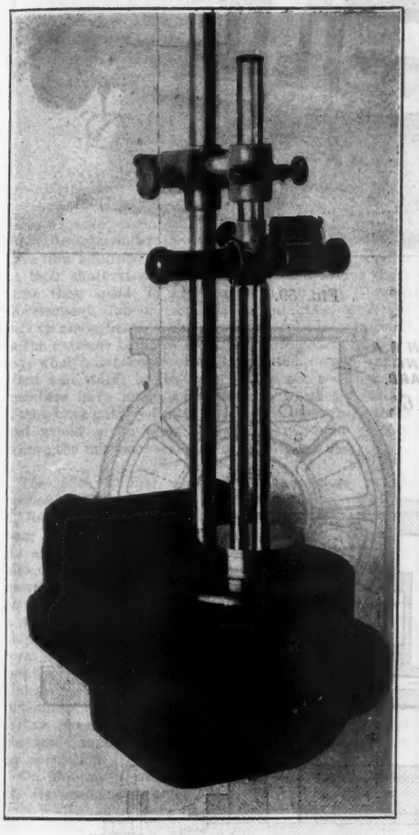


FIG. 56.

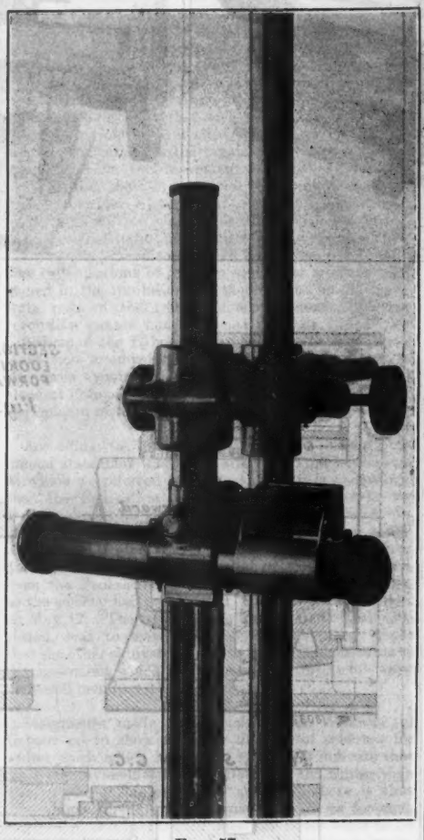


FIG. 57.

FIGS. 56 AND 57. COMPARATOR FOR CHECKING END-GAUGES; THE PITTER GAUGE AND PRECISION TOOL COMPANY, LIMITED, WOOLWICH.

Messrs. Nobel Industries, Limited, of Buckingham-gate, London, have a large display of explosives of various kinds suitable for duties ranging from heavy blasting work to charging sporting ammunition. Metal powders as used in metallic paints are also amongst their products, while many applications of "Necol plastic wood," which is so useful for fillet work in patternmaking and moulding artistic objects, are exhibited on the stand. The Premier Electric Welding Company, Limited, which is one of the constituent companies of Nobel Industries, Limited, are giving practical demonstrations, on another stand, of the ease and rapidity with which repairs can be effected by electric welding. An interesting application of their plant at sea was recently made in connection with the ss. Coronda. This vessel was carrying in its cargo a "Premier" portable engine-driven arc welding plant, for delivery to a customer in the Southern States, an expert operator for the set being amongst the passengers. During the voyage the low-pressure eccentric sheaf became loose, and before the trouble was located the keyway in the shaft had been very seriously injured. The Welding plant was taken out of the hold, unpacked, and used to repair the shaft, and after a delay of five hours the vessel was able to proceed.

Messrs. Boulton and Paul, Limited, of Norwich, have a very striking example of their water elevator, which consists of an endless belt hanging in the water to be lifted, and passing over a pulley at the top, by which it is driven. On the back of the belt is a cellular construction made by bending a strip of zinc into zig-zag shape and riveting the alternate pockets formed by the bending, to the belt. The zinc in no way affects the flexibility of the belt which is kept taut by a heavy flanged pulley hanging in the bight. When the belt is driven, it carries up water in and between the cells, and discharges it as the belt runs over the top pulley. The water-elevator on the stand is 40 ft. high and runs quite slowly so that the efficiency of the cellular pockets in holding the water can be easily seen. By means of such an elevator water can be raised from depths as great as 300 ft., and quantities up to 20,000 gallons per hour can be dealt with. The efficiency of the apparatus is quite good, a man being easily able to raise 2·8 gallons per minute from a depth of 220 ft. by his own power. The total absence of valves, stands, plungers or buckets is an obvious advantage, and the apparatus can be used in the dirtiest or grittiest water without any chance of injury or danger of becoming clogged.

The Pitter Gauge and Precision Tool Company, Limited, of Upper Market-street, Woolwich, are showing several cases of block gauges and slip-gauges in both English and metric sizes. The gauges made by this company are of such extraordinary accuracy and perfection that by "wringing" them together in suitable combinations any size from 0·2 in. to 36 in. can be obtained in steps of one-tenthousandth of an inch. The accuracy of the size so obtained is within one-millionth of an inch. There would be 55 gauges in all in such a set, and by the use of a subsidiary set of nine more gauges, every size from 0·3 in. to 36 in. can be obtained on steps of 0·00001 in. It is satisfactory to know that the perfection of these gauges, as certified by the National Physical Laboratory, is at least as high as the very best grade of Swedish gauges, and we understand the price of the British made gauges to be less. In addition to block and slip gauges the Pitter Company make end measuring bars up to 36 in. long. The standard measuring bars are guaranteed true to length within one part in a million and are a product which is probably unequalled in accuracy by any firm in the world. They are about $\frac{7}{8}$ in. in diameter with absolutely flat hardened ends, so that their accuracy is unimpaired by indefinite use. For workshop use measuring bars are supplied, of which the accuracy is guaranteed within five parts in a million, the ends being flat and parallel within the same limits. A set of 12 such bars will give all sizes from 2 to 39 in., in steps of 1 in., using not more than two bars at once. Used in combination with a set of 36 slip and block gauges, all lengths from 2 to 40 in. can be obtained, advancing by steps of one ten thousandth of an inch, or a set of 380,000 true sizes in all.

For measuring and compressing flat-ended bars, and standard block gauges, the comparator, illustrated in Figs. 56 and 57, has been developed by the Pitter Company. This can be provided to measure differences of length to a millionth of an inch, and yet it is so simple that any ordinary mechanic can use it without special skill or previous experience. It is, moreover, absolutely self-checking and does not depend upon any previous calibration for its

PROPELLER THRUST MEASURING DEVICE AT THE OLYMPIA EXHIBITION.

MICHELL BEARINGS, LIMITED, ENGINEERS, NEWCASTLE-ON-TYNE.

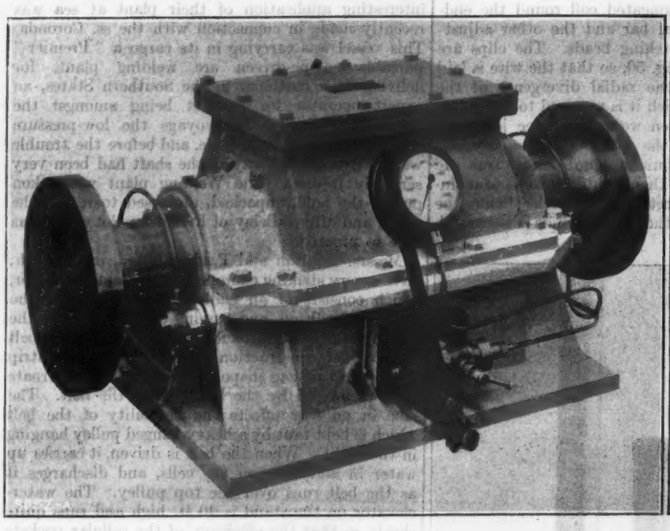


FIG. 58.

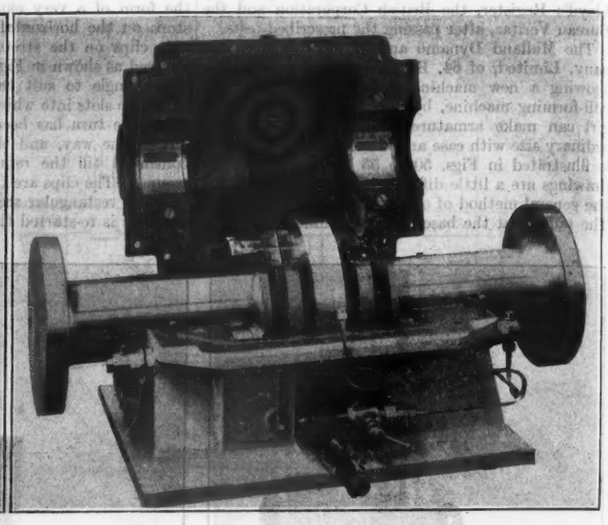


FIG. 59.

accuracy. The base is a rigid casting which is attached to the wall. On it is fitted a rotating table, which is flat and accurate to the order of a millionth of an inch. On a stout cylindrical bar fixed to the base and carried at its upper end by a small bracket not shown in the illustrations, is mounted the adjustable measuring head, illustrated to a larger scale in Fig. 57. The horizontal member of the measuring head contains an extraordinarily sensitive level tube, the holder of which has on its underside two steel balls which project through the containing tube. When the head is lowered on to its work one of these balls rests on each of the rods to be compressed, so that any difference in length of the rods causes the level to tilt. The position of the bubble is read in a mirror placed above the right-hand end of the tube. The mirror, which is set at an angle of 45 deg., is silvered all over except for two narrow horizontal bands which are left clear, and it is so mounted that when viewed in a horizontal direction, the scale which lies behind it is visible through the clear bands, while the reflection of the bubble is seen at the sides and between the views of the scale. A level-tube curved to a radius of 800 ft. and resting on two balls 0·4 in. apart, gives a magnification of 48,000 to 1, which is equivalent to a reading of 0·048 in. or practically a twentieth of an inch for a difference in length of one-millionth of an inch, in the bars being compared. The bars stand on the table of the machine, and after an observation has been taken the table is rotated through 180 deg. and the observation repeated, the total run of the bubble being taken into account in the computation given above. The rotation of the table and the cross-adjustments of the measuring head enable every portion of the ends of the bars to be brought under the measuring points.

An interesting exhibit at the stand of Michell Bearings, Limited, of South Benwell, Newcastle-on-Tyne, is a 7-in. thrust block fitted with a thrust-measuring device. We reproduce in Figs. 58 and 59 photographs of this exhibit, whilst its constructional details are shown in Figs. 60 to 62. The Michell pads *a*, Fig. 60, to which the propeller thrust is transmitted, are supported by two shoes, of which one (taking the thrust when the engines are reversed) is represented at *b* in the half-section, Fig. 60. In normal working these shoes abut upon fixed seats machined in the casing, but let into this casing at each end are two hydraulic jacks, the positions of which are indicated by dotted lines at *c* in Fig. 61. A section through one of the jacks is represented in Fig. 62. By means of the pump shown to the

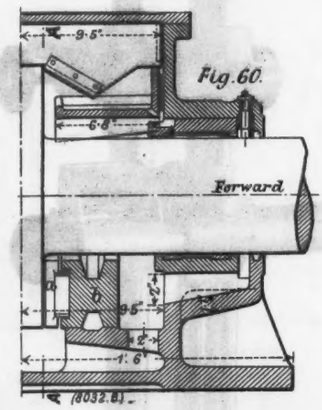


Fig. 60.

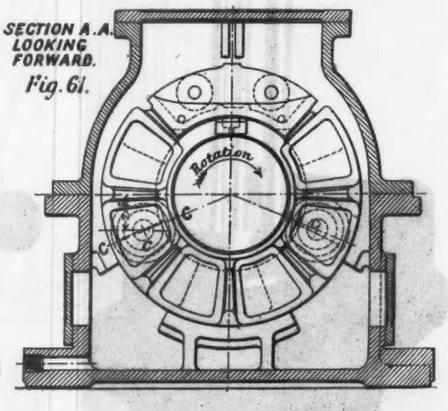


Fig. 61.

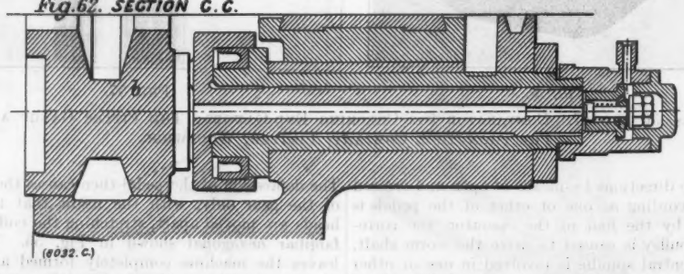
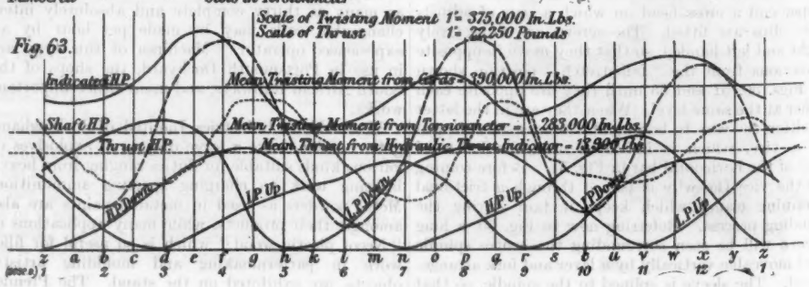


Fig. 62. SECTION C.C.

Full Line Curve shews Twisting Moment during one Complete Revolution Deduced from Indicator Cards.
Dotted ——— " " " " " " " Obtained from Flashlight Torsionmeter
Small Dotted Curve shews Thrust ..... " " " " " " Hydraulic Thrust Indicator
Lettered Ordinates Indicate Position of H.P. Crank
Numbered " " Slots in Torsionmeter

Fig. 63.


Scale of Twisting Moment 1" = 375,000 In. Lbs.
Scale of Thrust 1" = 22,250 Pounds
Indicated H.P.
Mean Twisting Moment from Cards = 390,000 In. Lbs.
Shaft H.P.
Mean Twisting Moment from Torsionmeter = 283,000 In. Lbs.
Thrust H.P.
Mean Thrust from Hydraulic Thrust Indicator = 13,800 Lbs.
H.P. Down
I.P. Up
L.P. Down
H.P. Up
I.P. Down
L.P. Up
z a b c d e f g h k l m n o p q r s t u v w x y z
(zero) 1 2 3 4 5 6 7 8 9 10 11 12 1

front in Fig. 58 the whole of the load can be transferred to the corresponding pair of jacks, one pair taking the load when running ahead and the other in running astern. The hydraulic pressure is, of course, proportional to the thrust and can be read from the gauge shown in Fig. 58. This arrangement is that used on turbine-driven steamers, where the torque is steady. For steamers driven by reciprocating engines the gauge is replaced by an indicator, and the cards thus obtained make it possible to plot curves showing the periodic fluctuation in the thrust and to compare this with the corresponding fluctuations in the torque. The curves reproduced in Fig. 63 were obtained from a twin-screw steamer having triple expansion engines with cylinders 15 in., 23 in. and 38 in. in diameter by 30 in. stroke, developing 929 i.h.p. at 151 r.p.m. The propellers were 7 ft. 6 in. in diameter by 12 ft. pitch and with a projected area of 25 sq. ft. The torque shown by the solid line was deduced from the indicator diagrams, and that by the long dotted line from the readings of a flash light torsion meter.

(To be continued.)

INDUSTRIAL NOTES.

WE referred on page 207 *ante* to a visit to Russia of a number of business men. The visit was arranged by Becos Traders, Limited, and the members of the mission anticipated being able to lay the foundation for future business in the country. The members have now returned from Russia, and from the reports on their short visit which we have seen in the daily press they speak in glowing terms of the Russian Government, labour, financial possibilities, &c. We believe many firms in this country would be interested in the extreme to know what will become, or, shall we say, what has become of all the British-owned works, plant and stores in Russia. We do not see that the members have made any reference to these points; if they have gathered satisfactory data concerning them and would make them known, they would greatly relieve the minds of many British business men.

The 55th annual congress of the trade unions opened at Plymouth last Monday; we deal with Mr. J. B. Williams' presidential address in an article on page 303 of the present issue. In the course of his address he stated that the past year had not been altogether a happy one so far as the co-operative movement was concerned. They had preached that this was akin to trade unionism, that it represented a more humane, sane and advanced form of relationship between employer and employed than the ordinary form of employment. They believed that to be true, but they wanted it to be true in substance and in fact. Unless, however, there was a broader view taken when differences arose than had been painfully evident in certain recent cases, there would be no alternative for the trade union movement but to replace advocacy by opposition.

On Monday a resolution was passed, calling upon the Government to amend the Old Age Pensions Act so that all qualified persons may receive the full pension, irrespective of any income received from any other source. Another resolution was passed for increasing the State pension to the blind, without any age limit.

The meeting on Tuesday opened with discussions of a political nature which are outside our scope, and should really be outside that of a labour congress also. There are many labour problems in this country which require settlement, and the time spent in dealing with the conditions of the German brothers, or "Kamerads," to give them the name which once upon a time they conferred upon themselves, is time lost. An idea of the difficulties to which we allude is afforded by the proceedings which followed at Tuesday's meeting. These proceedings had reference entirely to the "Back to the Unions" campaign. The title given at the Congress to this part of the proceedings is entirely wrong; the debates resolved themselves into heated altercations between leaders as to which unions any particular groups of men should belong. One speaker complained that the rivalries of the unions were causing many men to stay outside the movement; these men, and probably many union members also, came to the conclusion that the multiplicity of unions meant the keeping of secretaries or officials in jobs. An illustration was quoted to the effect that the Workers' Union was trying to disrupt the Transport Workers' Union. On the other hand, the latter body was accused of trying to take members from other unions, and the question was asked as to how the Transport Workers' Union could be entitled to members working in textile factories. The whole debate reveals the fact that the trade unions are in a state of chaos. This being the situation, what business have the "leaders"—who are in complete disagreement among themselves—to deal with foreign workers and with that absolute fallacy called "internationalism."

The proceedings at the Congress meeting on Wednesday included a discussion on the old-standing dispute between the National Sailors' and Firemen's Union and the Amalgamated Marine Workers' Union; this, we understand, was referred back to the Disputes Committee. Another dispute dealt with was that existing between the South Wales and Monmouthshire Mechanical and Surface Workers' Union, a union which has recently become independent of the South Wales Miners' Federation. In regard to this latter matter, the meeting endorsed the decision of the Disputes Committee, referring the application of the Surface Workers' Union for affiliation to the Congress. The election of a general secretary to replace Mr. C. W. Bowerman is to take place later, but the meeting decided that the new secretary to be appointed is to devote his whole time to the work, at a salary of 750*l.*, as against the 600*l.* now paid to Mr. Bowerman. The following resolution was then passed:—"That in the interests of the trade union movement this Congress deprecates the organisation of foremen, supervisory, technical staff, and other such workers in bodies promoted and jointly controlled by the employers, and strongly recommends the organisation of this class of workers inside the movement. As to the form of organisation, the Congress is of the opinion that foremen, supervisory, technical staff and other such workers should be closely identified with the unions in the various industries by such arrangements as may be mutually agreed to between the unions concerned." The organisations of foremen and other workers mentioned in the resolution are therefore to be invited to form part of the trade union movement. Another resolution passed had reference to trade boards, and called upon the Labour Party to resist to the utmost legislation intended to carry the recommendations of the Cave Committee into effect, and instructed the General Council to press upon the Minister of Labour the opinion of the Congress in regard to the matter.

According to the *Birmingham Post*, although no official statement was made after the York conference to which we referred in our last issue, it is understood that the Federation of Trades made it clear to the Boilermakers' Society that the agreement with the employers dated March 22 had been signed on behalf of all the federated trades, including the Boilermakers' Society, and that the expulsion of the boilermakers from the Federation was not in any way ante-dated, as the society had represented, but actually took effect on May 17. The result of the discussion at York, it is stated, was to leave the boilermakers in no doubt that the other shipyard unions looked to them to observe the agreement which had been entered into while they were still members of the Federation.

Statements made by officials at the Ministry of Labour go to show that the number of schemes for winter work which have been submitted indicate that more employment will be available for the winter than was originally contemplated, and that there is thus more hope for the unemployed as well as for men engaged in seasonal trades when the latter come to an end. The officials, it is reported, do not agree to statements recently made according to which local authorities are not speeding up work as much as they might do. Local authorities, the Ministry officials add, have responded to the invitation of the Government to apply for financial assistance in respect of relief works to a most gratifying extent, and if on examination the schemes submitted are found to be worth referring to the Department which makes the grants, there is every reason to believe that a great deal of work will be made available. It is claimed that the Ministry is doing its utmost to carry out all the promises made by Sir Montague Barlow in the House of Commons.

MECHANICAL STOKERS FOR MARINE WATER-TUBE BOILERS.*

A Few Results from Practical Experience with Mechanical Stokers Applied to Marine Water-Tube Boilers.

By W. J. MULLER, M.E. (Delft), Associate Member.

IT may be strange in these days of liquid-fuel-burning steamships to hear about experiments which have been carried out to investigate the possibilities of mechanical coal firing on board steamships. There is little doubt that liquid fuel has many advantages over ordinary bunker coal, but also one principal drawback, the price. The latter depends, more or less, on the quantity of crude oil which is found in different parts of the world, and it is certainly no secret that the quantity of petroleum residue available for burning purposes is still somewhat limited. It is also no secret that several shipping companies which started a few years ago to use oil fuel have recently converted a number of ships again to coal burning. After this conversion difficulties were encountered in some cases, owing to the labour necessary for hand firing, and for this reason attention has been drawn once more to the problem of mechanical stoking.

It is generally known that this problem is not at all a new one, and during the last twenty-five years more than one shipping company has tried the application of mechanical stokers on Scotch boilers. It is also known that these experiments have never proved to be a complete success, so that at this date the words of Mr. Arthur J. Maginnis,* in his paper concerning "The Advance of Marine Engineering in the Early Twentieth Century," delivered before the Institution of Mechanical Engineers at Liverpool on July 28, 1909, may be regarded as being still correct. It must be remembered, however, that this sentence more especially referred to experiments with mechanical stokers fitted in marine boilers of the Scotch type.

Since the introduction of water-tube boilers for ordinary mercantile steamships the situation has somewhat changed, and it is only fair to say that the satisfactory results which have recently attended the use of mechanical stokers on steamships in Holland have been obtained with water-tube boilers, as it was possible to apply mechanical stokers of standard design, as used in land boilers. Two cases in which mechanical stoking has been adopted on board steamships will be dealt with more particularly in this paper, as the experiments with them were carried out by the author for the Royal Steam Packet Navigation Company (Koninklyke Paketvaart Maatschappij) of Amsterdam. It may be of interest to know the reasons which have induced this company to investigate the possibilities of mechanical stoking as applied to steamships running on regular services in the Dutch East Indies.

Up to 1921 a great number of the Koninklyke Paketvaart Maatschappij's steamships used petroleum residue as fuel, and it may be mentioned here that this company started burning liquid fuel in marine boilers as early as 1900. It is also probable that nothing would have changed this practice if the price of Borneo liquid fuel, which in the earlier days of oil-burning used to be very cheap, had not gradually increased, until soon after the armistice the price reached such a height that it proved to be cheaper to burn native coal, even though inconvenient and more troublesome through the lack of skilled native firemen than to burn the ideal, but also most expensive, fuel. As the circumstances could not be altered the interest centred on the question of how to burn native coal so as to give the least trouble to the firemen with the best economic results.

Concerning mechanical stoking, the prospects were not bright having regard to what had been achieved before by other experimenters, but as something had to be done it was considered to be safest to start with a mechanical stoker in combination with a water-tube boiler of the Babcock and Wilcox type, of which several had been put in the Koninklyke Paketvaart Maatschappij's ships during the last ten years. The only difficulty was to decide upon the type of mechanical stoker to be tried.

Amongst the many systems of mechanical stoking which exist nowadays a few appear to be particularly suitable for water-tube boilers of the land type. These systems are:—A. The chain or travelling grate stoker; B, the sloping grate stoker; C, the underfeed stoker. The types mentioned under A and B have perhaps been applied most, as giving the best economic results, whereas the "Underfeed" type of stoker was at one time favourite for its simplicity and easy operation.

For marine stokers the first requirement is to be reliable, the second to be economic. This means that it should be possible first of all to work a marine stoker arrangement under any circumstances, even if the mechanical part goes wrong. In this last case the boiler must be free to be fired by hand. As the stokers mentioned under A and B are both of a type which cannot be fired by hand, the whole front being occupied by the feeding arrangement (hoppers and feeders or chain grate), there remained only the stoker of type C which can be fired by hand through ordinary fire-doors. The advantages of mechanical stoking over hand stoking are too well known to necessitate discussion in detail, one of the principal economic advantages of the leading designs is that the fuel (if of a volatile nature) is coked before combustion, thus permitting the gaseous products, which escape from the coal, to be burned separately from the coke which remains on the fire-bars: this is a very important item, as the two components of the original fuel require different conditions for perfect combustion.

After much consideration the Koninklyke Paketvaart Maatschappij decided to install a mechanical stoker of the "Underfeed" type into the main water-tube boiler (Babcock and Wilcox system) of two small cargo vessels, the Bintoehan and Parigi, of 1,200 tons and 1,500 tons deadweight capacity respectively. Both stokers have been supplied by the Underfeed Stoker Company, of London: the first one, placed on board the Bintoehan, being of the original standard design made by this firm; the second one, on the Parigi, being somewhat modified after experience obtained with the first stoker.

The following extract gives some of the practical results and the tests made during the trials with both

* Paper read at the Summer Meeting of the Institution of Naval Architects, held in Holland, September 5, 1923

* "A detail of considerable importance to the boiler-room is that of the adoption of mechanical stoking of some description. This, like other subjects, has been the cause of numerous experiments and patents, but so far it cannot be said to be so satisfactorily solved as to ensure universal adoption, although the Henderson system has been largely used."

ships. The general arrangement of the stokers may be seen from the drawing (see Fig. 1), which represents the arrangement as made for the Parigi. The stoker on the Bintoehan follows the original design, with the exception of the dump-trays, which for this ship were made single and without air spaces, no provision being made for the admission of any forced draught air supply to the ash pits. Also the fire-doors on the Bintoehan did not have the cooling device used in the stoker for the Parigi. As regards the design of the boiler on the Parigi, the average height of the water-tubes over the grate has been increased by 1 ft. 8 in., as compared with the height in the boiler of the Bintoehan, thus increasing the cubic capacity of the combustion chamber for reasons which will be explained hereafter. The position of the stoker front is not the same for both ships, as this front has been placed under the steam drum on the Bintoehan and in the rear wall of the boiler on the Parigi (see Fig. 2). The fuel used during the trials and also during the first voyage of both ships was South Yorkshire coal, which has much in common with the highly volatile native coals found in the East Indies, only being of better quality.

The stoker arrangement consists of a hopper (A) which is filled continuously by hand labour with coal, of which the bigger pieces have to be broken into smaller lumps before depositing into the hopper. From the hopper the coal is conveyed under the fire by means of a reciprocating sliding bottom (B), which runs the full length of the trough (C). As the coal rises from the trough it is distributed on the side-bars (D) and carried to the sides of the furnace until it is deposited at last on the dump-trays (E). This is performed by the action of the moving side-bars, which are made to rock or move alternately in a direction at right angles to the trough. The dump-trays are operated by levers placed on the outside of the furnace, thus enabling the ash and clinker to be automatically and periodically discharged into the ashpit (F) underneath the dump-trays.

By means of these arrangements the stoker is not only self-feeding but also self-cleaning, which is of great importance with native firemen who have to work the fires in the tropics. Besides this the stoker is a perfect coker, as the coal is, for the greater part, thoroughly degasified in the trough before it is deposited on the side-bars. This is especially important with volatile coal. The sliding bottom is actuated by a steam motor (G), the number of strokes of which may be varied from one in two or three minutes, to several in a minute, so that the rate of feed can be varied between considerable limits, which, of course, is necessary on board steamships. The rocking bars also receive their movement from the steam motor through the agency of two spirals placed outside the furnace and two nuts connected to the cross-head (H) of the steam motor and moving along the spirals. Thus the reciprocation of these nuts will cause the spirals, and likewise the side-bars connected to these spirals, to rock to and fro. The dump-trays are operated by hand, which can be done a few times during each watch if necessary.

Of special interest is the distribution of air which is admitted through an aperture (I) at the bottom of the wind-box (K). From this box it passes upward along each side of the trough (C), and is discharged, partly through a number of holes into the trough, partly through the hollow side-bars, which have no openings in their upper surfaces, so that the air has to pass along the whole length of the bars until it is discharged through an aperture at the other end of the bars into the enclosed air chambers (L), and passes from these chambers through the small air spaces between the bars to the fuel on the bars. It is obvious that by this arrangement the bars are kept cool by the air passing through them, and at the same time the air is heated before it enters the air chambers. The bye-pass, as shown in the drawing, to admit air from the air chambers (L) to the ashpits (F), was made for the stoker on the Parigi to ensure complete combustion of the fuel. This arrangement has not yet been applied to the first ship. The air-ports (M) over the trough have been made to admit secondary air into the combustion chamber, which arrangement is essential for perfect combustion of volatile coal, though it does not seem to be a general practice yet with marine water-tube boilers. The quantity of secondary air, depending on the fuel used, can be varied in this arrangement by means of a damper.

SS. Bintoehan, tests a and b.—The results of these tests, as given in Table I, on page 299, show that at a rate of about 5 lb. per square feet of heating surface per hour of steam production the boiler efficiency is approximately 65 per cent., which is certainly not a striking figure. As is shown in the accompanying table the most important losses have been the thermal losses in the escaping gases (funnel losses), due to the heat which was still left in these gases after having passed the heating surface of the boiler. These losses amount to about 20 per cent., whereas the remaining losses (being the sum of the thermal losses by radiation together with the ash and the losses unaccounted for) represent about 15 per cent. of the original calorific value of the fuel.

To reduce the funnel losses, which as a matter of fact never can be entirely avoided, the surplus of combustion air and also the temperature of the escaping gases should be kept as low as possible. The high temperatures stated during tests *a* and *b*, however, should not be considered in connection with the stoker only, as similar temperatures happen to exist in hand-fired Babcock and Wilcox boilers of the same construction. Investigations on several boilers of the same design have shown the author that improvements as regards this matter can be made only by the adoption of a variable secondary air jet of large capacity into the combustion chamber and by increasing the cubic capacity of this chamber.

Concerning the remaining losses, if the insulation has been properly made (as on the Bintoehan), the loss through radiation should not exceed 5 per cent., which leaves 10 per cent. for the losses unaccounted for and the thermal losses in the ash and clinker. As these thermal losses are never very high it was plain that the losses unaccounted for on the Bintoehan had to be reduced considerably. The latter were found to be due partly to imperfect combustion of the gases and partly to imperfect combustion of the solid fuel on the side-bars. This was proved by analysis of the waste gases, which always showed the presence of one or more per cent. of unburnt gases (carbon monoxide), even with *smokeless combustion*, and by examination of the ash and clinker, which apparently could not be completely burnt. This must be put down to the rather heavy rate of consumption of 25–26 lb. of coal per square foot of grate area per hour which again was a result of the relatively small grate area in proportion to the heating surface (1 : 42·5); the grate area in this case is taken to be the area of the grate-bars only, excluding the trough and the dump-trays. It will be clear that improvements could only be made here by increasing the effective grate surface, as has been done on the Parigi, by admitting air to the ash pits under the dump-trays, thus enabling the area of these trays to be included as effective grate surface.

The practical results of the trial trips and the first voyage of the Bintoehan may be summarised as follows:—

1. Constant steam pressure through constant steam production.
2. Smokeless if not quite perfect combustion.
3. Easy work for the firemen, consisting merely in continuously throwing small quantities of broken coal into the hopper and dumping the ash trays a few times per watch; removing eventual clinker through the fire-doors if too big to be carried automatically to the dump-trays.
4. No sticking of clinker to the side-bars.
5. Equal depth of the fuel on the side-bars (3–4 in.), not affected by the rolling of the ship.
6. Overheating of the fire-doors.
7. Overheating and distortion of the dump-trays.
8. Incomplete combustion of the solid fuel on the fire-bars.
9. No difficulty with hand-firing if not steaming at full power.

To these points it may be added, that the fan engine had to be used constantly as the small air spaces between the bars required a certain pressure in the air chambers to produce a sufficient air-blast through these spaces.

SS. Parigi, tests c to f.—From the experience gained with the Bintoehan during the erection of the second stoker a few alterations were made to the arrangement for the Parigi, which have been already mentioned and which are illustrated in Figs. 1 and 2. From the results, as given in Table I, it may be seen that under almost equal circumstances, as compared with the trials with the first ship, the boiler efficiency of the Parigi has been considerably improved. A comparison of the figures of tests *b* and *d* shows that for a steam production of respectively 4·95 lb. to 5 lb. of steam per square foot of heating surface per hour the coal fired per square foot of grate area per hour was 24·7 lb. for the Bintoehan against 18·2 lb. for the Parigi, this reduction being largely due to the increase of the active grate surface of the latter by arranging the dump-trays as secondary grates. By this arrangement it has been possible to burn the solid fuel on the side-bars almost perfectly, thus leaving practically no fuel to be lost with the ash and clinker. Another improvement is shown by the average temperature of the escape gases on the Parigi, as compared with the Bintoehan, *e.g.*, in tests *b* and *d* these temperatures were 340 deg. and 290 deg. C., respectively, which means a decrease of 50 deg. C. These temperatures, together with the average CO_2 percentages in the waste gases, account for the thermal funnel losses, which during tests *b* and *d* were 20·1 per cent. and 15·4 per cent., respectively. This improvement must have been due to the increase of the combustion chamber cubic capacity, which affects the combustion of the gases in such a way that practically no combustion takes place outside

Fig. 1. UNDERFEED MECHANICAL STOKER ARRANGEMENT FOR S.S. PARIGI (KONINKLYKE PAKETVAART MAATSCHAPPIJ OF AMSTERDAM.)

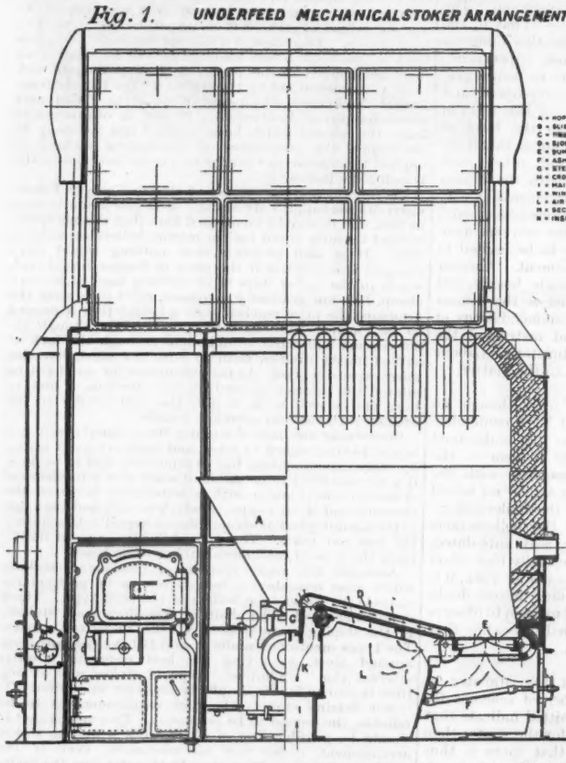

A = HOPPER
B = SLIDING BOTTOM OF TROUGH
C = TROUGH
D = SIDE BARS, ALTERNATELY FIXED AND MOVING
E = DUMP TRAYS
F = ASHPIT
G = STEAM MOTOR
H = CROSSHEAD
I = MAIN AIR INLET
K = WINDBOX
L = AIR CHAMBER
M = SECONDARY AIR PORTS
N = INSPECTION HOLE

Fig. 2.

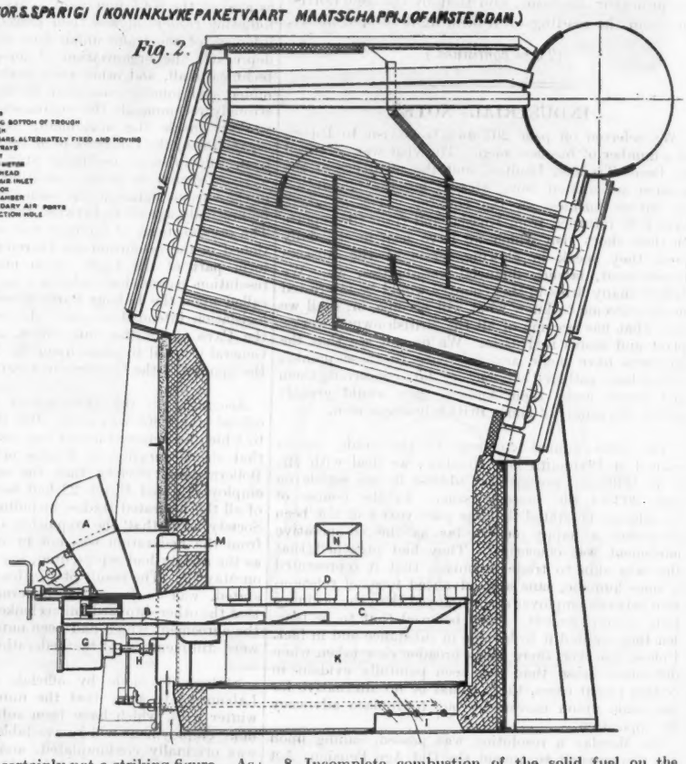


TABLE I.

Steamship	Bintoehan.		Parigi.			
Boiler system	Babcock and Wilcox.		Babcock and Wilcox.			
Stoker system	Underfeed.		Underfeed.			
Heating surface, square feet	2,174·4		2,325			
Actual grate area, square feet	51·7		70			
H.S./G.A.	42·5		33·2			
Average height of lower water-tubes over grate, feet	4·0		5·7			
Combustion chamber, cubic feet	240		400			
Dump-trays	Single.		Double, with air-spaces.			
Test	*a*	*b*	*c*	*d*	*e*	*f*
Coal	S. Yorks. Hards.	S. Yorks. Hards.	S. Yorks. Hards.	S. Yorks. Hards.	S. Yorks. Hards.	S. Yorks. Hards.
Quality of coal	Fairly good.	Fairly good.	Good.	Good.	Good.	Good.
Fixed carbon, per cent.	54·15	59·38	56·54	59·63	59·63	59·63
Volatile matter, per cent.	31·86	32·91	31·80	30·89	30·89	30·89
Water, per cent.	7·34	4·19	6·59	4·24	4·24	4·24
Ash, per cent.	6·65	3·52	5·07	5·24	5·24	5·24
Calorific value, as fired, B.T.U.'s per pound	12,430	13,570	12,620	13,230	13,230	13,230
Duration of test, in hours	11	16	22	17·5	145·5	190
Average steam pressure, pounds, per square inch	180	180	174	180	180	180
Steam evaporated, total in pounds	115,390	172,480	224,620	204,050	1,541,100	1,835,460
Steam per square feet of H.S. per hour, pounds	4·82	4·95	4·4	5·0	4·56	4·15
Coal fired, total in pounds	14,850	20,240	24,930	22,440	164,120	193,950
Coal per square feet of G.A. per hour, pounds	26·2	24·7	16·2	18·2	16·1	14·6
Steam per pound of coal (from and at 100 deg. C.), pounds	8·45	9·28	10·1	10·13	10·4	10·4
Ash removed during test, pounds	1,122	1,474	Not measured	Not measured	14,022	17,490
Average CO_2 in funnel waste gases, per cent.	11·6	11	11·4	12·2	11·8	12·5
Temperature of funnel waste gases, in degrees C.	370	340	270	290	295	283
Average air pressure at fan, inches	2	2	1	7/8	1	1
Boiler efficiency, per cent.	64·5	64·8	75·5	73	75	75·7
Thermal loss in waste gases, per cent.	20·7	20·1	15·5	15·4	16·2	14·7
Unaccounted for, radiation, ash, per cent.	14·8	15·1	9·0	11·6	8·8	9·6

Fig. 3.

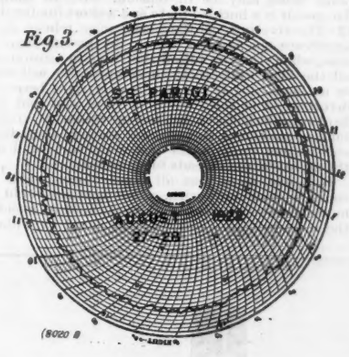
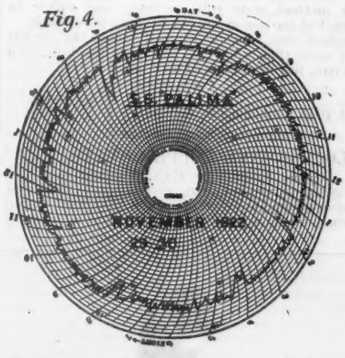


Fig. 4.



the combustion chamber, and thus no heat is generated by the gases after they have entered the rows of water-tubes, a condition which permits of the reduction of the temperature of the escaping gases to a minimum.

The improvement in combustion in the boiler of the Parigi may be seen from the figures indicating the remaining losses, which for tests *b* and *d* were 15·1 per cent. and 11·6 per cent. respectively. This improvement has been confirmed by the analysis of the waste gases, which on the Parigi only indicated *traces* of carbon monoxide. Tests *e* and *f*, which give the results recorded during the first voyage of the Parigi from Amsterdam to Batavia, demonstrate that the figures obtained during the trials *c* and *d* could be maintained on a long voyage. As regards the practical results of the stoker on the ss. Parigi, the trouble experienced in the first ship with the dump-trays and the fire-doors appeared to be wholly eliminated by the efficient cooling arrangement of the second ship.

A few words may be said about the records, which during the tests (*e* and *f* included) were taken by specially selected men used to this kind of work and not belonging to the engine-room staff; every precaution was taken to prevent serious mistakes being made. The coal used was weighed continuously and the steam production indicated by water meters, was checked before and after the trials to ensure correct readings. Analysis of waste gases was made by Orsat tests as well as by permanent indicators. An illustration of the constant steam pressure which could be permanently maintained without the slightest difficulty is shown by the pressure chart of the Parigi, taken during the first voyage of this ship (August 27–28, 1922). For comparison a similar pressure chart of a sister ship, the Palima (November 29–30, 1922), has been added, from which may be seen the periodic fall of pressure at the beginning of each new watch (12, 4 and 8 o'clock) (Figs. 3 and 4 above).

The Bintoehan has been in regular service now for more than 18 months, and the Parigi for more than 12 months. During this time no serious trouble has been experienced, and both stokers are reported as still working satisfactorily.

Concerning the figures given in this paper as compared with other results, the author has found that 65 per cent. to 68 per cent. boiler efficiency with hand-fired Babcock and Wilcox boilers on 20-hour trial runs, with ordinary coal, may be considered as being a maximum for this type of hand-fired marine boiler on long voyages. Whether the application of mechanical stoking for water-tube boilers can effect any saving as a whole will depend on the circumstances. Certainly the mechanical stoker has one outstanding advantage, viz., that it makes the shipowner almost independent of firemen. And this is perhaps the most important item, because if the results have to depend on the behaviour of the personnel it may in some cases be more economical to eliminate the human element by having a mechanical device doing the work and doing it constantly.

THE ROYAL SANITARY INSTITUTE.—The Royal Sanitary Institute has issued a pamphlet indicating the various lectures and demonstrations which are to take place during the autumn term. Forms of application and all particulars can be obtained from the Institute, 90, Buckingham Palace-road, S.W.1.

PERSONAL.—It is anounced that the business of Messrs. Armstrong and Main, Limited, has now been completed. The name of the company has been changed to A. and J. Main and Co., Limited. All present branches will be retained. The firm's Clydesdale Works in Glasgow and the Calcutta Bridge and Roof Works in Calcutta are fully equipped for dealing with the various classes of steel structural work.

THE LATE MR. MALCOLM HAY.—Many in the steel and engineering trade will learn with regret of the death of Mr. James Malcolm Hay, at Bude, on the 19th May. Mr. Hay was almost throughout his whole life associated with Col. T. E. Vickers and Mr. Albert Vickers, He was appointed a Director of the Vickers Company in March, 1889, continuing at Sheffield until 1898, when he went to the Barrow works. Ten years later he retired, after a connection with the company extending over thirty-seven years.

WHITWORTH SOCIETY.—The President, Dr. H. S. Hele-Shaw, has arranged the following programme for Tuesday, September 11, with the management of the International Shipping, Engineering and Machinery Exhibition, Olympia, London, W. Reception at 4.30 p.m. by Dr. H. S. Hele-Shaw, Chairman of the Committee of Experts; 4.45 p.m. tea; 7.30 p.m. dinner (morning dress). About 90 Whitworth scholars have intimated their intention to be present. The Hon. Secretary, Whitworth Society, c/o Institution of Mechanical Engineers, Storey's Gate, Westminster, S.W.1, will be pleased to hear at once from any scholars who have not already received notice.

TEMPERATURE MEASUREMENTS IN RUBBER TYRES.

Two methods have been used for determining the operating temperatures of pneumatic tyres. The first method deduces the temperature in the rubber from the pressure-volume changes of the air in the inner tube; the method is laborious, only suitable for the laboratory, and gives merely average readings, which are sometimes as much as 60 deg. F. below the actual temperature of certain parts of the tyre body. The second method makes use of thermocouples. According to an article by Ellwood B. Spear and J. F. Spurdy, of the Goodyear Tyre and Rubber Company, Akron, Ohio, published in the August issue of *Industrial and Engineering Chemistry*, these couples were first inserted between the plies of the tyres when building; but the wires soon broke in service. The couple wires were then introduced, by means of an awl, into holes drilled into the tyre to depths of 1¼ in. maximum. Again the readings obtained proved too low, apparently because the contact area between the wires and rubber was too small, the heat being conducted away by the wires at a faster rate than it would be replenished by so bad a heat conductor as rubber.

After many experiments the following device was adopted. The thermocouple is placed within a hollow cylinder turned out of hard maple wood, in which it is embedded in powdered magnesia. The upper portion of the cylinder has a diameter of ¼ in., the lower a diameter of ⅛ in., the upper end is closed by a plug of the same wood, through which the terminals of the copper-constantan wires pass; the lower end is closed by a copper disc which is soldered to the ends of the wires, forming a thermo-junction of comparatively large surface. The cylinders are inserted into holes drilled into the bore and the holes are plugged with rubber. With these devices it had been found that when the temperature of the tyre is 60 deg. F. at a depth of 0·2 in., the temperature will be about 40 deg. at a depth of 2 in. As the temperature of the rubber rises near the surface the gradients become steeper. When 300 deg. F. are reached outside, the temperature inside will only be about 85 deg. F. A correction of about 6 deg. F. has generally to be applied. When a reading is to be taken the rubber plug is removed after stopping the car, and the measurements are made as quickly as possible to minimise the influence of cooling; the correction mentioned depends upon the rate of cooling. The drilling of the holes in the tread of a tyre to receive the cylinders of the thermocouples is said to injure the tyre less than might be expected; holes have been drilled through nine plies of 12-ply tyres without materially shortening the life of the tyre. The method has been in use for a year now; no premature separation of the plies has so far been observed.

STEEL BRIDGE FOR MOROCCO.—H.M. Consul-General at Tangier has forwarded to the Department of Overseas Trade a copy of a specification, in French, relative to a call for tenders by the Shereefian Government (Commission Générale des Adjudications et des Marchés) for a double-span steel bridge over the Oued M'da on the Tangier-Fez railway. No plans are available. The quantities are given as follows: 1st span of 12·6 metres, weight of materials 23,650 kilos. Second span of 26·46 metres, weight of materials 72,600 kilos. A preliminary deposit of 2,500 francs and a final deposit of 5,000 francs are required. The adjudication takes place on October 25. The specification (but no drawings) is available for inspection by United Kingdom firms at the Department of Overseas Trade, Room 50.

FOREIGN VISITORS TO THE SHIPPING, ENGINEERING AND MACHINERY EXHIBITION.—Mr. Frederic W. Bridges, Organising Manager of the Exhibition, writes to us as follows:—May I be allowed, through the medium of your journal, to issue on behalf of the President, Committee and Management of the Shipping, Engineering and Machinery Exhibition, a most cordial invitation to all overseas engineers and others in any way connected with the shipping, engineering and machinery industries, to attend the dinner to be given at the Exhibition on Thursday, September 13, at 7 p.m., in honour of overseas visitors at present in this country. I will be happy to forward tickets admitting both to the exhibition and dinner to all who apply up to the morning of the 12th inst. Mr. Bridges' address is Avenue-chambers, 4, Vernon-place, Southampton-row, London, W.C.1.

LIFE-SAVING APPLIANCES ON PASSENGER VESSELS.—In an interesting and important paper read yesterday before the Institute of Marine Engineers at a meeting held at Olympia in connection with the Shipping, Engineering and Machinery Exhibition, Mr. Ernest W. Blocksidge reviewed the question of the provision of life-saving appliances on large passenger vessels. His conclusions were in general agreement with the recommendations of the Merchant Shipping Advisory Committee which were dealt with in our issue of May 25 last on page 657. He suggested, however, that it was undesirable to continue to use the available space on the top deck of a vessel for the stowage of large rafts or pontoon lifeboats which could only be used after the vessel has sunk and they had floated clear, expressing the view that the light form of buoyant apparatus which was immediately available for use on either side of the vessel would be preferable. The paper also referred to the importance of providing the greatest number of embarking stations permitted by the length of the vessel and to the high value of motor boats as a part of the statutory equipment. Several interesting examples of modern life-saving equipment were illustrated and described in an appendix to the paper.

THE LATE DR. E. K. MUSPRATT.

THE death of the veteran chemical manufacturer, Edmund Knowles Muspratt, who died at Seaforth Hall, Liverpool, on Saturday, September 1, in his ninetieth year, will cause widespread regret and will cast a shadow over the coming British Association meeting owing to his activities in the earlier proceedings of the Association, and the fact that the meeting is to be at Liverpool. Dr. Edmund Muspratt was the last representative of the second of three generations of the family, the founders of the alkali industry on the Lower Mersey, and eminent in the industrial, intellectual and political life of Liverpool and district.

His father, James Muspratt, was born in Dublin in 1793 and died in 1886 at Seaforth Hall. He was apprenticed to a druggist, but joined Wellington's Army in 1812, and later served also in the Navy, but in 1822 he started the manufacture of prussiate of potash soda by the Leblanc process and sulphuric acid in Liverpool with so much success that two new works were soon opened at St. Helens and Newton. Together with C. Tennant, of Glasgow, he also introduced, in 1839, pyrites in the place of sulphur for the manufacture of sulphuric acid, and on the instigation of Liebig he founded chemical manure works in 1866. The elder of his two sons, James Sheridan Muspratt, was equally successful, but was not granted a long span of life; born in 1821, he died in 1871. He studied in Giessen and Munich, established and conducted a college of chemistry at Liverpool, and was author of a dictionary of chemistry, one of the first of its kind, which was published in two volumes in Glasgow in 1853. The German "Muspratt, Encyclopädie der Technischen Chemie," which Stohmann and Kerl subsequently compiled in seven bulky volumes, was based upon Muspratt's work.

Edmund Knowles Muspratt himself was the youngest son of James Muspratt. Born at Linacre, near Bootle, on November 6, 1833, he was educated at the Pestalozzi school of Worksop, at which particular attention was paid to science and modern languages, and went in 1850 to Giessen to study chemistry under Liebig. Having become Liebig's assistant in the small university of the Grand Duchy of Hessen, he took up physiological chemistry as a research subject and followed Liebig to the university of Munich. But the problems of industrial chemistry and of economics attracted him more strongly, and he returned soon to England to take up the management of his father's works at Widnes and Liverpool. The works adopted the Weldon process for the recovery of manganese in the generation of chlorine from manganese dioxide and hydrochloric acid—the Weldon process was very important in those days, but has been superseded since by electrolytic methods of chlorine preparation—as well as the Ludwig Mond's process for the extraction of sulphur from alkali waste. Muspratt also tried the ammonia-soda process, in which many chemical manufacturers failed for various reasons until success was finally achieved by Solvay. The name of Muspratt and Eschellmann is connected with a process for the preparation of potassium chlorate. By 1890 the works of Muspratt and Sons and of Muspratt and Huntley were, together with several others, incorporated in the United Alkali Company, of which Muspratt was vice-chairman at the time of his death. He was also chairman of the British Insulated and Helsby Cables, Limited.

In these and in other appointments which he held Muspratt was less the active chemist than the administrator and organiser, and he took a strong interest in the affairs of his birthplace and country. The Society of Chemical Industry, which he had helped to found, elected him its fourth president in 1885; the address, which he delivered when retiring at the Liverpool annual meeting in 1886, will remain a valuable record of the development of the chemical industry on the Mersey. He was president of the Liverpool Chamber of Commerce in 1875. In 1877 he became a member of the Liverpool Town Council, on which he remained till 1886; in this period fell the adoption of the Vrynwy water supply scheme for Liverpool, which he supported. In the years, 1889 to 1902 he was a member of the Lancashire County Council. Educational matters and the foundation of the University of Liverpool, in particular, were the chief aspirations of his later years. He had not forgotten that he had had to study metallurgy in the cellars of Owen's College at Manchester. He spent 17,000*l.* on the building and equipment of the chemical laboratory of the new university, and he always remained ready to assist by word and deed. He was Pro-Chancellor of the University for the period 1903 to 1909, and the LL.D. degree which it conferred upon him in 1907 was well deserved.

A man of wide interests, he came into personal contact with many literary men. He was an advocate of Mill's "Political Economy," an ardent free trader, and sided with the North in the American Civil War. His one book—apart from papers—"My Life and Work," is more entertaining and instructive on general questions than on the chemical industry. Mr. Muspratt married in 1860 Miss Frances Baines, daughter of Thomas Baines, who had been proprietor of the *Liverpool Times*. Muspratt was himself connected with the Liverpool press. A man of remarkable activity, he was able to attend meetings occasionally till last year. But blindness threatened him while he was writing his book, and he was much confined to his house during the last years. His wife died in 1910, leaving three sons and four daughters. Two of the sons, Sir Max Muspratt, Bart., now chairman of the United Alkali Company, and Mr. Horace Muspratt, a director of the same company, are maintaining the tradition of the family not alone as manufacturing chemists.

"ROTATING DISCS OF CONICAL PROFILE."

TO THE EDITOR OF ENGINEERING.

SIR,—It has been pointed out to me that instead of using the method of successive approximation described towards the end of my article of last week, the direct algebraical method can be used if preferred. Thus, substituting equations (3) and (4) in equations (5) and (6):

$$44800\, q_c + A\, q_1 + B\, q_2 = \sigma\, t_1 = 7{\cdot}96 \times 10^5 + 2{\cdot}66\,(44800\, p_c + A\, p_1 + B\, p_2)$$

$$44800\, q_c + A\, q_1 + B\, q_2 = \sigma\, t_2 = 2{\cdot}85 \times 10^5 - 62{\cdot}325\,(44800\, p_c + A\, p_1 + B\, p_2)$$

(q_c q_1 q_2 p_c p_1 p_2 are not the same in both equations. They each have a certain value at the hub and another at the rim.)

This reduces to:

$$21050 + 3{\cdot}323\,A - 27{\cdot}46\,B = 0$$
$$12750 - 288{\cdot}7\,A + 23{\cdot}00\,B = 0$$
$$\therefore A = 105{\cdot}6 \quad B = 780.$$

With this method, slide rule accuracy may suffice in many cases, but the use of four figure logs. is desirable.

The method can also be applied when the profile consists of more than one cone, or where the hub, or a very deep rim, has been treated as a parallel disc.

Yours faithfully,

B. HODKINSON.

Trafford Park, Manchester, September 3.

LOCOMOTIVE COPPER STAYS.

TO THE EDITOR OF ENGINEERING.

SIR,—Recent researches on the subject of screw threads have opened our eyes to much that we had not hitherto considered of much importance. On ordinary bolt and nut work we have come to realise that "fit" is a quality that is not essential nor even desirable; that to secure interchangeability and the maximum mechanical strength the only provisos are (1) that there shall be a definite but small clearance between the largest screw and the smallest nut; (2) that effective diameter and pitch are the chief elements on which to concentrate our efforts, keeping them within predetermined tolerances; (3) that full and core diameters do not matter as long as they clear as between bolt and nut.

This means that even on the highest grade of screwed work there may be and usually will be a certain slackness of "fit," and the nearer the screw and nut agree in pitch the more slackness there will be. Every engineer who has studied the latest developments in the manufacture and gauging of screwed work will concede these points.

The knowledge gained on commercial bolt and nut work, however, is of no avail when we come to consider the requirements for copper stays. The slackness permissible, nay desirable, in bolt work is fatal in a copper stay as water could percolate through the space between the threads on the stay and in the plates. Riveting the head over may tend to correct this, but, owing to the alternations of stresses in working, can only serve to delay the leakage. Interchangeability is just as desirable in copper stays as in bolt work, but—and this is where our knowledge is at present deficient—the methods of securing interchangeability in the one cannot be used in the other.

The three desirable elements in a copper stay are: (1) Water tightness; (2) uniformity of stresses on all stays; (3) long life.

Is it possible to ensure these three and still make all stays interchangeable? There is room here for a very keen discussion before we can arrive at definite conclusions. Water tightness is absolutely essential even at the expense of the other two items. Under present conditions it can be obtained by making one or more elements of the stay threads on the large side so as to make the stay tight in the two plates. This is reinforced by riveting the heads over. What is the result of this? (1) The threads are deformed on insertion and it is uncertain what this deformation is. It may lengthen or it may shorten the pitch, and when all stays are screwed home some may be in tension, some in compression. The result is a buckled plate and a short life for the stays. (2) The riveting of the heads may relieve or it may aggravate the stresses set up by assembling. In any case, when steam is raised the stays in tension will take all the load while those in compression will take little or no load. (3) If the stay is only tight because of the deformation of the threads on crest and root while the flanks are out of contact the operation of riveting will tend to make the threads still slacker, a condition that still further imperils the water tightness and decreases the ability of the threads to stand load.

It would seem that all these objectionable features could be done away with, water tightness could be made more permanent, uneven stresses could be avoided while the manufacturing end could be eased by widening the tolerances, if certain changes could be made in the design of copper stays. If, therefore, the pages of ENGINEERING could be opened to a discussion of this subject the result should be a considerable gain to our knowledge and an increase in the efficiency of our locomotives.

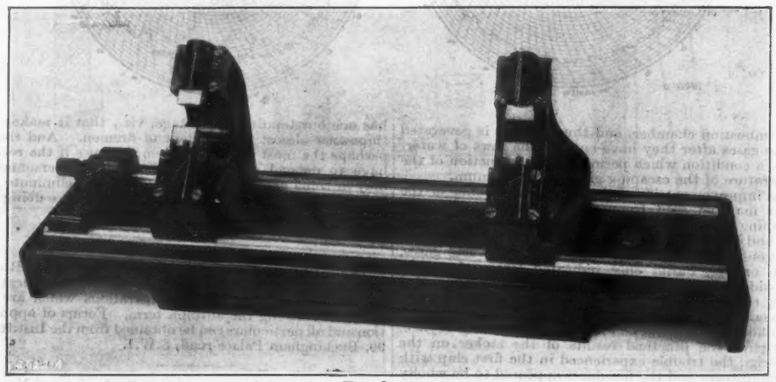


FIG. 1.

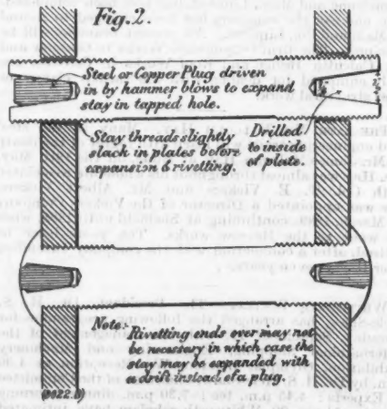


Fig. 2.
Steel or Copper Plug driven in by hammer blows to expand stay in tapped hole.
Stay threads slightly slack in plates before expansion & rivetting.
Drilled to inside of plate.
Note:- Rivetting ends over may not be necessary in which case the stay may be expanded with a drift instead of a plug.
(922.b)

We think we know what the theoretical requirements are, but we are entirely in the dark as to the practical means to be taken to comply with them. We therefore hope that those with more practical knowledge than ourselves will help to enlighten us and others by discussing this subject in your pages. The suggestion set up as a beginning of this discussion is as follows:—

Copper stays should be threaded with standard dies to fine tolerances, but with a definite clearance in the tapped hole.

The stay tap should have threads of similar form to the dies; this means that there will be no greater clearance on crests and roots than there will be on the flanks.

The stays should be gauged by three separate tests, viz.: (*a*) full form "go"; (*b*) effective diameter "not go"; (*c*) continuity of pitch. The type of gauge suggested for these tests is shown in Fig. 1.

The slackness there will be between the stay and the plates under the above system of inspection to be neutralised by expanding the ends of the stay in the plates, either instead of or before riveting the heads. The expansion of the ends could be done as shown in the adjoining sketch, Fig. 2, by hammering two taper plugs into tapered holes and then riveting over in the orthodox way. By this means riveting could not possibly slacken the stay as all threads would be engaged as tightly as possible first. The taper of the plugs

would be a matter of experiment. It should be coarse so that slight variations in drilling depth and plug diameter would not affect the endwise position of the plug.

There may be unseen difficulties in this, but there is no doubt that there is room for considerable improvement from all points of view—cheapness of manufacture, efficiency in working and economy in replacements.

It is hoped that those of your readers who are better informed of the essentials required will give us the benefit of their views through the medium of your correspondence columns.

We are, yours faithfully,
ALFRED HERBERT, LIMITED.

August 22, 1923.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—A few optimists are to be met with among trade organisers in the steel and engineering branches, but the prevailing spirit for the most part is one of growing concern at the sluggish rate of recovery. Indeed, in certain sections, matters are definitely worse than they were six months ago, and the condition of order books indicates that trying times are likely to be experienced during the coming winter unless an early improvement takes place. Shipbuilding requirements, for which Sheffield specially caters, are kept at a very restricted level, and though forges and foundries are to some extent benefiting from armament orders only partial employment is possible. Hope centres largely in the development of electricity schemes at home and abroad, and in the improvement of transport services in other directions. The half million pounds contract placed with Metropolitan-Vickers, Limited, of Manchester, by the Southern Railways will find a certain amount of work for Sheffield in the construction of motors. Very little that is favourable can be reported about special steel or high speed tools. Inquiries from the Colonies are perhaps a shade more numerous, but the percentage of these materialising in actual business is low. Uneven conditions obtain in soft steel. While some of the local plants are engaged at quite two-thirds capacity, others are standing idle, and this despite the fact that prices have been pruned so as to allow a minimum of profit. Some of the tool-making departments are maintaining a substantial output in face of keen competition from America. Australia is a good buyer of light steel products. The cutlery trades continue to absorb a big tonnage of stainless steel, principally for table knife manufacture. In raw and semi-finished materials, prices remain stationary, with a slightly firmer tendency induced by the restricted output.

South Yorkshire Coal Trade.—Only the insistent call for best steams for export enables collieries to maintain rates at their current level. Home industrial users would eagerly welcome lower charges, but see little hope of inducing these while the Continental call continues so insistent. More slacks are available, but an even demand is maintained despite the slump in Lancashire buying. Cobbles and nuts are a moderate market. Coke deliveries to home users are again suffering from the strength of the shipping inquiry. Quotations :—Best hand picked branch, 30*s.* 6*d.* to 32*s.* 6*d.*; Barnsley, best Silkstone, 26*s.* 6*d.* to 28*s.*; Derbyshire best brights, 25*s.* to 27*s.*; Derbyshire best house, 22*s.* 6*d.* to 23*s.* 6*d.*; Derbyshire best large nuts, 20*s.* to 21*s.* 6*d.*; Derbyshire best small nuts, 15*s.* to 16*s.*; Yorkshire hards, 21*s.* to 23*s.*; Derbyshire hards, 20*s.* to 22*s.*; rough slacks, 11*s.* 6*d.* to 13*s.* 6*d.*; nutty slacks, 10*s.* to 12*s.*; smalls, 7*s.* to 9*s.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Another reduction in Cleveland pig-iron quotations has caused no surprise, but a feeling now prevails that a further fall will not occur at all events for some little time, with the result that customers show rather more disposition to negotiate for autumn supplies. Foundries are reported a little busier, and as they are understood to have only small stocks of pig-iron a little expansion of home trade may be looked for. Export business is very quiet. No. 1 is now obtainable at 103*s.* 6*d.*; No. 3 g.m.b. is quoted 97*s.* 6*d.* No. 4 foundry is no more than 92*s.* 6*d.*; and No. 4 forge is down to 90*s.*, at which figure a little mottled and white has also been purchased. All the foregoing quotations are f.o.t. makers works and f.o.b. Tees.

Hematite.—East Coast hematite continues to be characterised by pronounced firmness, and demand is reported fairly good both for home use and for shipment abroad. Output is now no more than sufficient for current needs. The minimum home and export price of Nos. 1, 2 and 3 is now 98*s.* 6*d.*, and some makers are asking up to 100*s.*

Foreign Ore.—Imported ore is lifeless with market quotations still based nominally on 23*s.* c.i.f. Tees for best rubio.

Blastfurnace Coke.—Durham blastfurnace coke keeps scarce and is in the neighbourhood of 41*s.* delivered.

Manufactured Iron and Steel.—There is slightly more inquiry for one or two descriptions of finished iron and steel, but business matures slowly. Quotations :—Common iron bars, 12*l.*; iron rivets, 14*l.*; packing, 8*l.* 10*s.* to 11*l.* 10*s.*; steel billets, 9*l.* to 9*l.* 5*s.*; steel ship, bridge and tank plates, 9*l.* 15*s.*; steel angles, 9*l.* 5*s.*; heavy steel rails, 9*l.* 10*s.*; and galvanised corrugated sheets, 19*l.*

Imports of Iron and Steel to the Tees.—Returns have just been issued by the Tees Conservancy Commission giving detailed iron and steel imports to Teeside from Holland, Belgium, France, Norway, Sweden, Germany and coastwise, for the ten months ending August 31 last, as compared with the same time a year ago, and with the corresponding pre-war period of 1913–14. They reveal that the unloadings of pig-iron for the past ten months amounted to 11,035 tons, against 34,268 tons a year ago, and 312 tons for the pre-war period. Imports of crude sheet bars, billets, blooms and slabs for the months just ended reached 60,331 tons, as against 47,197 tons a year ago and 33,646 tons for the pre-war period. Plates, bars, angles, rails, sheets and joists brought to the Tees during the past ten months are given at 10,315 tons, as against 5,528 tons a year ago, and 19,441 tons during the pre-war period.

Shipments of Iron and Steel from the Tees.—Shipments of iron and steel from the Tees last month—including 8,204 tons of pig-iron loaded at Skinningrove—amounted to 75,120 tons, 34,795 tons being pig-iron, 1,877 tons manufactured iron, and 38,448 tons steel. Of the 26,591 tons of pig iron sent from the port of Middlesbrough 23,819 tons went to foreign ports and 2,772 tons went coastwise, Germany again being the best customer with an import of 11,648 tons; whilst Denmark took 2,526 tons; the United States 1,900 tons; Italy 1,800 tons, and Scotland 1,665 tons. As regards manufactured iron, 1,150 tons went abroad and 727 tons went coastwise, the Straits Settlements being the largest buyers, receiving 314 tons. Of the steel shipped 30,430 tons went overseas and 8,018 tons went coastwise, the principal customers being: India, 5,272 tons; New South Wales, 3,930 tons; Cape of Good Hope, 3,209 tons; Natal, 2,693 tons; Victoria, 2,578 tons; Japan, 2,231 tons; Canada, 1,966 tons; and the Argentine, 1,328 tons.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—There has been little or no change in the conditions prevailing in the Scottish steel trade this week. Makers continue to experience difficulty in securing fresh business, and orders on hand are not nearly sufficient to keep more than a section of the plant running. Not only is the home trade very poor and without any life, but export business is very scarce also. No change having taken place in the shipbuilding industry the demand from that quarter is negligible, and while there is a certain amount of activity in structural sections and for galvanised sheets on export account the trade passing in black sheets is not very heavy. Prices are unchanged and are as follows :—Boiler plates, 13*l.* per ton; ship plates, 10*l.* per ton; sections, 9*l.* 15*s.* per ton: and sheets, 12*l.* 10*s.* per ton, all delivered Glasgow stations.

Malleable Iron Trade.—In the malleable iron trade of the West of Scotland there is no improvement to report. Makers are still meeting with a very poor demand and the outlook is not bright. Neither home nor export orders are easy to obtain, and until the Ruhr position becomes easier improvement in business is bound to be slow. The price of "Crown" bars is steady at 12*l.* per ton, delivered Glasgow stations.

Scottish Pig-Iron Trade.—A dull time still prevails in the Scottish pig-iron trade, and the demand is not sufficient to clear outputs with the result that stocks are increasing. Unless a change for the better comes along soon there is a possibility of several furnaces being damped down or blown out altogether. Prices have an easier tendency, and in the case of a favourable line producers are inclined to shade quotations. The following are the current prices :—Hematite, 5*l.* 5*s.* per ton, delivered at the steel works; foundry iron, No. 1, 5*l.* 5*s.* per ton, and No. 3, 5*l.* per ton, both on trucks at makers' yards.

Scottish Pig-Iron Shipments.—The export of Scottish pig-iron from Glasgow Harbour for the week ending last Saturday, September 1, amounted to 1,008 tons. Of that total 914 tons went foreign and 94 tons went coastwise. For the corresponding week of last year the figures were 2,120 tons overseas and 88 tons coastwise, making a total shipment of 2,208 tons.

Scottish Shipbuilding.—Depressing conditions are general in the shipbuilding trade throughout the country, and although many were hopeful that last week's conference between the Federation of Engineering and Shipbuilding Trades and the Boilermakers' Society would lead to some sort of arrangement which would tend to end the present dispute nothing satisfactory seems to have been arranged. The result is that the boilermakers lock-out continues and the yards remain idle. The prospects in the industry are very black just now and the oncoming winter is not being looked forward to with any hopeful feeling. With regard to output, the past month has been one of a disappointing nature. The total output of new tonnage was as follows :

	Vessels.	Tons.
The Clyde	9	1,865
The Forth	1	150
The Dee and Moray Firth ...	1	175
	11	2,190

The Clyde total was the second lowest of the year and only brings the year's output to 148,276 tons, and for a similar output for the corresponding period we require to go back over thirty years. No new contracts were reported for the month of August, and the position in the industry at present is that unless the boilermakers' dispute is settled soon even the little work now going on at the various yards will cease altogether.

NOTICES OF MEETINGS.

THE INSTITUTE OF METALS.—Monday, September 10, to Thursday, September 13. Autumn meeting at the College of Technology, Sackville-street, Manchester. Monday, September 10, at 8 p.m., at Milton Hall, 244, Deansgate, Manchester. Second Annual Autumn Lecture on Subjects of Practical Interest to those Engaged in the Non-ferrous Metals Industry. "The Use of Non-Ferrous Metals in Engineering." By Lieut.-Colonel Sir Henry Fowler, K.B.E. Tuesday, September 11, at 10 a.m. at the College of Technology, Manchester. Papers to be read and discussed. "The Cause of Red Stains on Sheet Brass," by Mr. E. A. Bolton, M.Sc.; "Note on Brinell Hardness Numbers," by Mr. H. W. Brownsdon, M.Sc., Ph.D., F.I.C.; "The Behaviour of Metals under Compressive Stresses," by Mr. W. I. Coe, M.Sc.; "On the Measurement of the Change of Volume in Metals during Solidification," by Mr. Hikozô Endo; "The Electrochemical Character of Corroaion," by Mr. Ulick R. Evans; "The Constitution and Age-Hardening of the Quarternary Alloys of Aluminium, Copper, Magnesium, and Magnesium Silicide," by Miss Marie L. V. Gayler, M.Sc.; "Investigation of the Effects of Impurities on Copper. Part I—The Effect of Oxygen on Copper," by Mr. D. Hanson, D.Sc., Mr. C. Maryatt, B.Sc., and Miss Grace W. Ford, B.Sc.; "Experiments with Some Copper Wire; Cohesion a Function of both Temperature and Cold-work," by Mr. Douglas H. Ingall, M.Sc. Note on "The Effect of Small Quantities of Nickel upon High-Grade Bearing Metal," by Mr. A. H. Mundey and Mr. C. C. Bissett, B.A., B.Sc., B.Met.; "Stereotyping," by Mr. A. H. Mundey and John Cartland, M.Sc.; "Hardness Tests on Crystals of Aluminium," by Mr. Hugh O'Neill, M.Met.; "A Dilatometric Study of the Transformations and Thermal Treatment of Light Alloys of Aluminium," by Mr. Albert M. Portevin and Mr. Pierre Chevenard. Note on "Effects of Rate of Cooling on the Density and Composition of Metals and Alloys," by Mr. R. C. Reader, Ph.D., M.Sc.; "Crystallisation Effect on Galvanised Iron Sheets," by Mr. E. L. Rhead, M.Sc., and Mr. J. D. Hannah; "Equilibrium in the System Gold-Zinc (based on Investigations of Electrical Conductivity at High Temperatures)," by Professor P. Soldau. Visits to various works. Wednesday, September 12, at 2 p.m. Visit to Manchester Ship Canal. Thursday, September 13, at 9.30 a.m. Visit to Chester.

THE INSTITUTION OF AUTOMOBILE ENGINEERS.—September 19, 1923, at the Shipping Exhibition, at Olympia. 11.30 a.m., "Reversing Systems of Large Marine Oil Engines," by Miss V. Holmes. 2 p.m., "Small Commercial Marine Motor Design," by Arthur F. Evans. 4.30 p.m., "Small Marine Engine Design," by Basil H. Joy.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—For loading during the next fortnight supplies of most classes of coal are still freely available at prices which are dependent on the individual circumstances of buyer and seller. After this, salesmen are reluctant to accept fresh commitments at current values, while buyers generally are not disposed to pay higher levels. The hesitancy of operators in regard to forward business is due to the possibilities of the future caused by the Greeko-Italian trouble and the American anthracite miners' strike position. The outstanding feature of the coal trade during the past week has been an advance of 9*d.* to 1*s.* in freight rates to Italy, but even so, this has brought freights to West Italy up to only 9*s.* 6*d.* compared with an average rate of 12*s.* 10½*d.* in March and 10*s.* in June. The increase was caused by an increase in the number of orders which came into the market for West Italy following the assassination of an Italian general and the crisis which arose with Greece. The news that the American anthracite miners had come out on strike also caused a hopeful feeling, but so far inquiries have come into the only market for odd cargoes. It must, however, be remembered that it was not until last year's strike had been in progress quite two months that the Americans placed orders for Welsh coal in any quantity. As the winter months are close at hand it is, however, not likely that should the strike continue, that buying will be held off for so long this time though the requirements, unless the stoppage spreads to the soft coal men, are not likely to be as heavy as they were last year. Still it would not require a vast amount of new business to send prices up for, notwithstanding the apparent day to day inactivity on the coal market, exports keep up fairly well as regards volume which signifies that collieries must be pretty well sold on contract account and thus have not a great deal to offer on the market. For prompt loading best Admiralty large coal is round 30*s.* with best drys at the same figure, but second class Admiralty and dry large can be secured at 28*s.* with small concessions possible for spot loading. The leading Monmouthshires range from 27*s.* to 29*s.* Smalls of practically all classes are in plentiful supply. Coking sorts command from 22*s.* to 23*s.*, with best bunkers from 19*s.* to 21*s.*, and the inferior grades from 14*s.* up. Coke is a quiet market at 40*s.* to 50*s.* for export, and patent fuel, too, is inactive at 30*s.* to 33*s.*

TELEGRAPHIC ADDRESSES.—The 1923 midsummer supplementary issue of Sell's Directory of Registered Telegraphic Addresses, with telephone numbers and special classified trades list, is now available. It can be obtained from Business Directories, Limited, 8 and 9, Johnson's-court, Fleet-street, E.C.4.

THE "VICKCEN" CENTRIFUGAL OIL SEPARATOR AT OLYMPIA.

CONSTRUCTED BY MESSRS. BRITISH SEPARATORS, LIMITED, ENGINEERS, LONDON.

(*For Description, see Page* 309.)

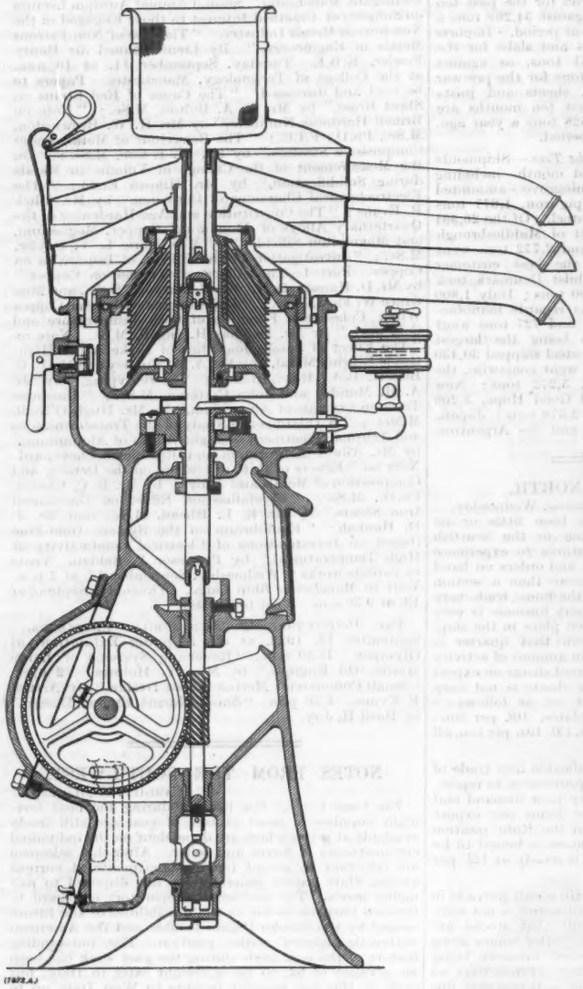


FIG. 1.

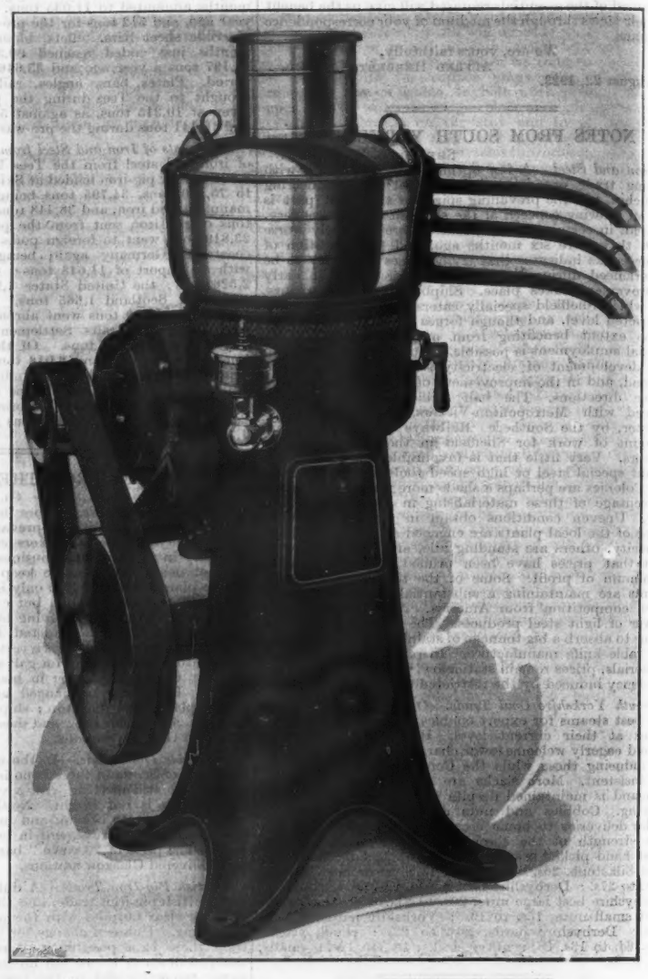


FIG. 3.

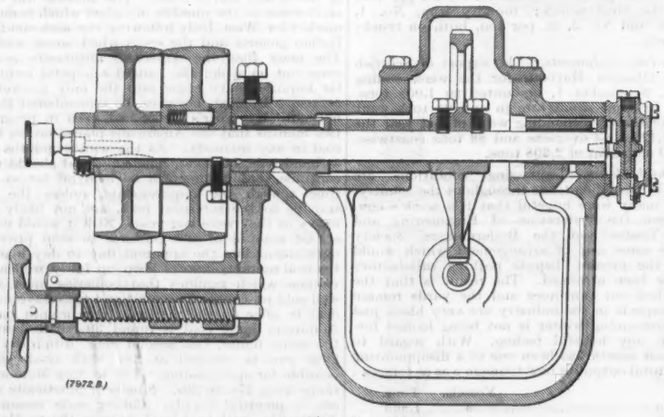


FIG. 2.

FIG. 4.

ROLLS-ROYCE AERO ENGINES.—In view of the extreme importance of reliability in aero engines it may be of interest to call attention to the results obtained between October 1, 1922, when the various air lines on the London-Paris route commenced to operate under the Government subsidy scheme, and July 31 last. In this period the number of engine trips made on the route in question was 1,212 and the number of engine hours flown was 3,380, while 5,077 passengers were carried and the total mileage covered was 278,000. Rolls-Royce engines are exclusively employed on this service and Messrs. Rolls Royce, Limited, inform us that, for the whole of the period referred to, no failure resulting in injury or loss of life to passengers has been recorded. This fact is certainly good evidence of the high degree of reliability and endurance achieved by the Rolls-Royce engine.

INSTITUTION OF THE RUBBER INDUSTRY.—This institution has issued a folding card giving the dates of meetings and the titles of the papers to be read at them for the London, Manchester and other sections. The address of the Institution is Faraday House, 10, Charing Cross-road, W.C.2.

EXHIBITS AT THE SHIPPING, ENGINEERING AND MACHINERY EXHIBITION AT OLYMPIA.

(For Description, see Page 292.)

Fig. 35.

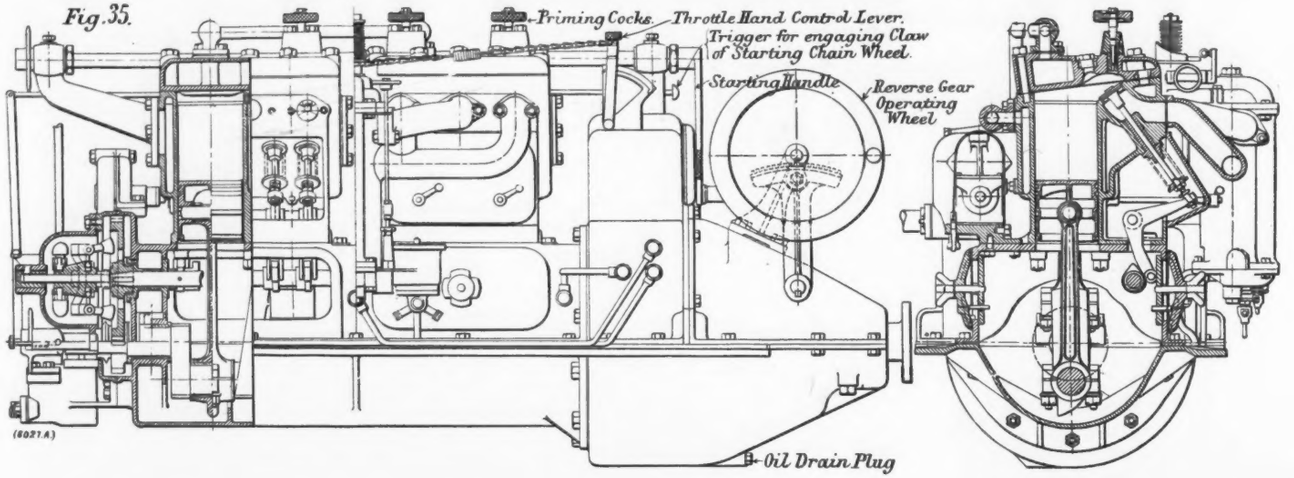
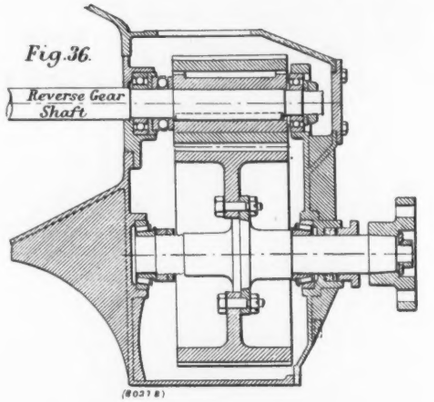


Fig. 36.



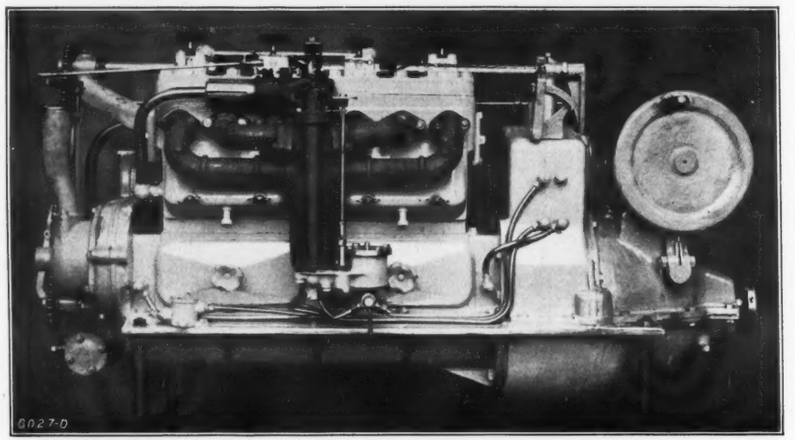


FIG. 37.

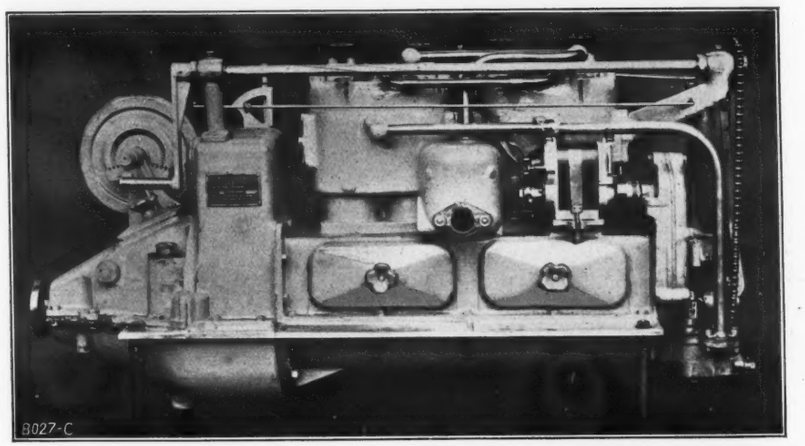


FIG 38.

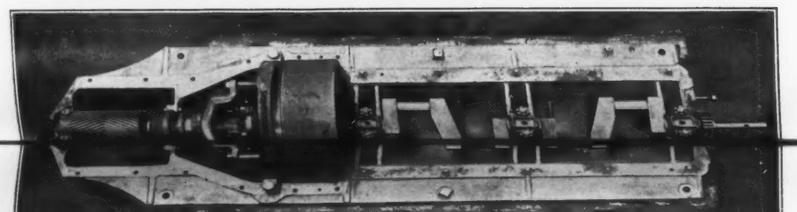


Fig. 43.

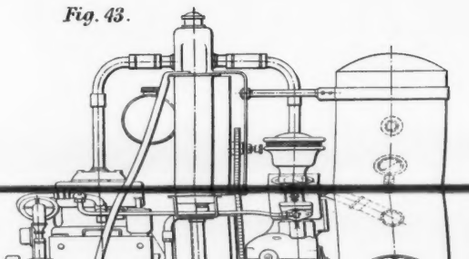
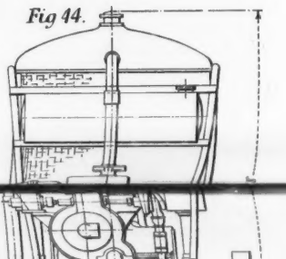


Fig 44.



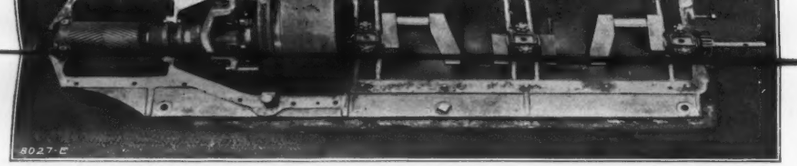
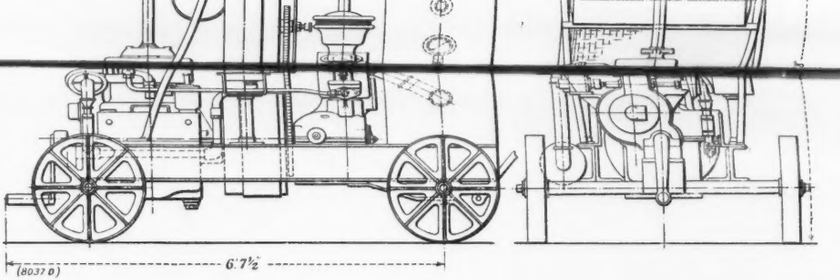
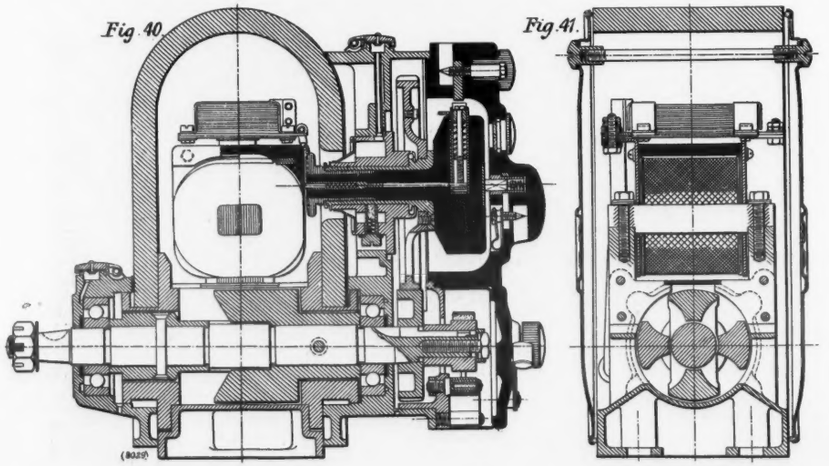


Fig. 39.

Figs. 35 to 39. 24–28-H.P. Engine for Motor-Boats: Messrs. Gleniffer Motors, Limited, Glasgow.





Figs. 40 and 41. Magneto (Polar Induction Type): The British Thomson-Houston Company, Limited, Coventry.

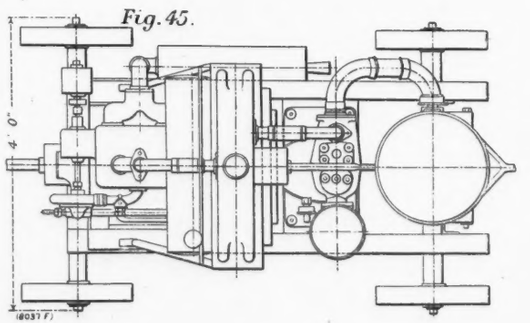


Fig. 47.

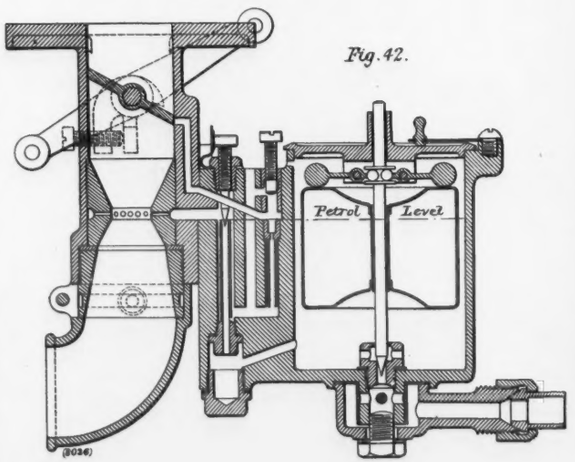


Fig. 42. Degory Carburettor: The Degory No-Jet Carburator Company, Limited, Fulham.

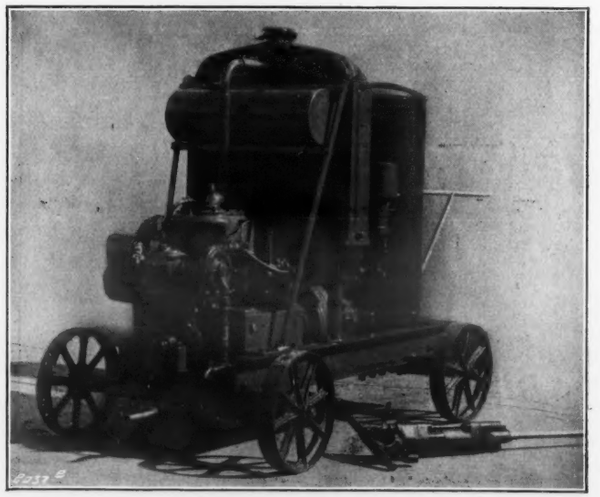


Fig. 46.

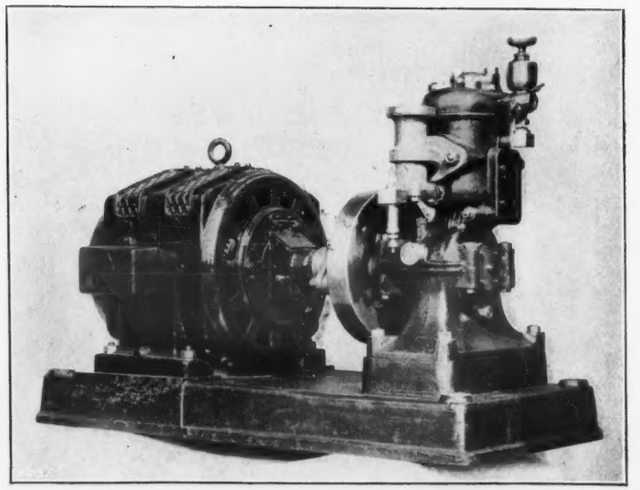


Fig. 48.

Figs. 43 to 46. Portable Petrol-driven Air Compressor. Fig. 47. Rotary Blower driven by Electric Motor.
Fig. 48. Motor-driven Air Compressor: Messrs. Lacy, Hulbert and Co., Limited, Beddington, Croydon.

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CONTENTS.

	PAGE
Reciprocal Load Deflection Relationships for Structures (*Illus.*)	287
The Gas Engine Power Station of Palmers' Shipbuilding and Iron Company (*Illus.*)	288
The Shipping, Engineering and Machinery Exhibition at Olympia (*Illus.*)	292
Industrial Notes	297
Mechanical Stokers for Marine Water-Tube Boilers (*Illus.*)	297
Temperature Measurements in Rubber Tyres	299
The Late Dr. E. K. Muspratt	300
Letters to the Editor.—"Rotating Discs of Conical Profile." Locomotive Copper Stays (*Illus.*)	300
Notes from South Yorkshire	301
Notes from Cleveland and the Northern Counties	301
Notes from the North	301
Notes from the South-West	301
Notices of Meetings	301
Trades Unionism	303
The Progress of Aeronautical Research	304
Britain and Japan	304
Radio-Telegraphic Direction Finding by Reception	305
The Stamped or Pressed Metal Wares Trade Board of Inquiry	307
The Institution of Naval Architects in Holland	307
Notes	309
The "Vickcen" Centrifugal Separator (*Illus.*)	309
Diagrams of Three Months' Fluctuations in the Prices of Metals	310
Dutch River Lighters (*Illus.*)	311
The Water-Tight Sub-Division of Passenger Ships (*Illus.*)	314
The Sub-Division of Large Passenger Steamers (*Ill.*)	317
ENGINEERING Patent Record (*Illus.*)	319

Two-Page Plate.—EXHIBITS AT THE SHIPPING, ENGINEERING AND MACHINERY EXHIBITION AT OLYMPIA.

ENGINEERING.

FRIDAY, SEPTEMBER 7, 1923.

TRADES UNIONISM.

IN the last two years trade union organisations in this country have lost some two million members and the rate of loss is still rising. To outsiders this would appear a serious matter, but little or no attempt to deal with it was made in the President's address to the fifty-fifth Trade Union Congress which opened at Plymouth on Monday last. This omission is illustrative of one of the serious weaknesses of official labour. Mr. J. B. Williams, the President, certainly pointed out that the Congress was attended by 702 delegates, representing 4,369,268 trade unionists, as compared with 560 delegates, representing 2,232,446 trade unionists attending the Manchester meeting in 1913, but he avoided any examination of the causes of the serious falling off in membership of the last few years. It is certainly usual for the president of any organisation, in his formal address to it, to refrain from important criticism and to look at its activities with optimistic eyes, but there are probably few presidents outside labour circles who would be able to treat the membership losses which trade unionism is sustaining in the incidental way which apparently contented Mr. Williams.

We do not know whether the latest President of the Trades Union Congress did not find it necessary, or did not find it possible, to explain the present-day loss of trade union membership, but the matter appears of sufficient importance even to outsiders to merit a little examination. The falling-off may certainly partly be explained by the state of trade and the present widespread unemployment. Similar conditions have always led to similar losses. It must also be remembered that many unions achieved greatly swollen membership during the war, and that a readjustment between the total membership of any craft union and the normal total work available for that membership had sooner or later to be made. It is not possible to estimate matters of this kind quantitatively, but it seems probable that after making full allowance for these two causes there still remains a very large falling-off on membership unaccounted for. We suggest that this balance may not be unconnected with the present political policy of most of the unions.

Mr. Williams, in his Presidential Address, stated that the decision taken by the Trades Union Congress at Plymouth in 1899 to create a political wing of the Labour movement was the most important action ever taken in that town and surpassed the sailing of Drake to defeat the Armada, or to the setting-out of the Pilgrim Fathers. This again is a matter which we find it difficult to estimate quantitatively, but there can be no question but that the decision has been of serious importance to Labour. So much is this so that the word "Labour" has come to have an almost entirely political significance in every-day usage. Whether this is, or is not, a good thing in itself is a matter of opinion, but if the majority of trade unionists are not satisfied that their unions should be mainly political organisations the great decision made at Plymouth may ultimately lead to the break-up of the unions as we now know them.

With the population of this country constituted as it is, Labour representation in Parliament is both desirable and inevitable, but the present close connection between such membership and the trade unions is neither desirable nor, in our opinion, inevitable. Some connection there probably must be, but the more trade unions can confine themselves to their original business of watching the interests of labour in industry and can bring themselves to leave politics alone the more effective they are likely to become. The predominant place which politics have taken in trade union activities was illustrated very clearly by Mr. Williams' address, which was largely concerned with the Near East, Air Force expenditure, the Italian-Greek crisis, and other subjects which seem to have singularly little relation to trade unions and the wages and working conditions of the working man. This preoccupation with outside affairs can hardly be explained by any lack of trade union matter requiring comment and discussion in a year which covers the fall in membership we have referred to, the boilermakers' strike, the revolt in the dockers' union, and the present unemployment.

One of the serious features of this preoccupation with politics is that false interests and false values are introduced, and the real problems facing labour are forced into the background. No better nor more insistent examples of the problems which organised labour must tackle if it is to survive could be found than those furnished by the dockers' revolt and the boilermakers' strike, and a leadership which is incapable of facing, or afraid to face, such questions can lead to no effective goal. We are aware that individual unions are jealous of their autonomy and status, and that the Transport and General Workers' Union would listen with impatience, if at all, to any comments on their recent activities from a member of the Musicians' Union, even if he is temporally a Trades Union Congress president, but it was in no way necessary or desirable that Mr. Williams should have entered into the merits of any particular trouble or dispute. The question of trade union discipline is a general one which must be fairly faced if official trades unionism is to attain the status which is desirable. The present state of affairs is simply one of muddling along, and allowing revolts and undisciplined actions to settle themselves in the best way they may at serious loss to trade union funds and status and to the country at large.

The present undiscipline is certainly traceable in considerable measure to the political activities of the unions. These breed the idea that any trouble is best met by political action, and that unemployment and a falling standard of living which affect labour so acutely, instead of calling for fair examination, are best met by criticism of whatever Government may be in office and general comments about the construction of society. A fair and impartial examination by the Trades Union Congress into the effect of the boilermakers' revolt on the funds and unemployment percentages of other unions is, we are afraid, too much to ask for, but the elected representatives of labour should surely be able to discuss the question of trade union discipline in general terms and at least tentatively examine methods of dealing with it. A real attempt of this kind would do much to stabilise

the unions and would improve both their status and their strength. A body which appears to be mainly occupied with vague political activities cannot be surprised if its individual members are apt to estimate lightly the importance of the real duties which it itself neglects. The more the unions stick to their own business and discharge it effectively the less trouble will they have with their own members.

An effort of this kind would also do much to check the fall in membership. There is an idea abroad that labour leaders have to go pretty well where they are pushed, and the proceedings of some of them suggest that they themselves agree. Some individuals, and notably Mr. Thomas and Mr. Bevan, have never failed to be outspoken when they thought it necessary, but something more than isolated and individual effort is required. It is a mistake to suppose that a union which demanded and enforced obedience to its rules and recognition of its engagements from its members would be a weak union. On the contrary it would be strong. The average man has little initiative and prefers to be ruled. With the present jealousy and competition between unions it is difficult for any but the strongest bodies to act towards their members always as widely as they might, but if trades unionism generally at its annual congress could see its way to devote its time to a proper consideration of the internal questions which are its real problems, a basis might be laid on which the unions could build up an authority and a standing greatly in advance of any they now possess. There is nothing impossible in a union attaining an authority and status which no individual member would think of questioning and which would attract the worker who is now alienated. Such a position can, however, only be attained by a devotion to trade union matters and a very material slackening of the political connection.

THE PROGRESS OF AERONAUTICAL RESEARCH.

WHILE the value of research work in industry is now more generally realised than was formerly the case, the business man, as a rule, is still inclined to regard expenditure on it as wholly unproductive unless it is directed towards the solution of some specific problem of immediate importance. He has little sympathy with fundamental research work which will certainly occupy much time and may, or may not, yield useful results. Yet it is on this latter class of work that real progress depends, and this is particularly true in the case of aeronautics, the fundamental principles of which are still only imperfectly understood.

The report of the Aeronautical Research Committee, which has just been published for 1922–23, records continuous progress, although it refers to no feature of outstanding importance as having resulted from the year's work. The Chairman, Sir R. T. Glazebrook, again draws attention to the small proportion of the total vote for supply and research which is allotted to fundamental research. He points out, what will be obvious to all who have studied the subject, that the results of research cannot usually appear in production until some years later, so that the effects of inadequate provision will be felt not so much at the present time as in future years. The Committee, as a whole, consider that the best results to the State would accrue from the retention of the services of the technical staffs at the various research establishments, with adequate provision for mechanical staffs and material. Expenditure incurred in this direction, they consider, would be more profitable than that involved in giving prizes in connection with competitions which represent only limited lines of attack on the problems of flight.

The most important part of the Committee's work concerns the research programmes in hand at the Royal Aircraft Establishment and at the National Physical Laboratory, and while full use has been made of the equipment at the latter, the curtailment of the staff for running the wind channels at the first-mentioned establishment has retarded the progress of some of the investigations. Safety being a primary consideration in flying, a considerable amount of model and full-scale work has been carried out in connection with the stability and control of aeroplanes. The determination of stability derivatives on complete models has been continued at the National Physical Laboratory, and from this, and other model work, full-scale research on control above the stalling angle has been made possible. For further full-scale research work, three two-seater biplanes are to be constructed for purely experimental purposes and two of these machines have already been ordered. These machines will first be used for experimental flying at attitudes above the stalling angle, and they will doubtless add materially to existing knowledge of the problems of stability and control under such conditions. Having been specially designed for research work they will doubtless be of great value for the investigation of other problems, and since three machines will be available it will be possible to keep one of them continuously in use while the others are undergoing repairs or modifications.

Other aerodynamic work referred to in the report is that on scale effect which has now advanced sufficiently to enable the Committee shortly to review the whole position and to bring up-to-date the report on the subject issued some five years ago. Attention has also been given to the matter of sound production by airscrews and to the application of the Prandtl theory to aeroplane wings and airscrews. Some work on seaplanes has also been carried out, and, in the current year, it is proposed to commence a programme which will include the investigation of the stresses in hulls when alighting or travelling on the water, the investigation of methods of construction and structural design, and an investigation of the effects of steps and loading on stability.

The work on engines has included some tests on engines of foreign design and construction, and although one of the engines tested was found to have an exceptionally low fuel consumption, the causes for which are being investigated, it is interesting and satisfactory to note that the engines generally had a greater weight per horse-power than average British engines of the same period, and were not superior from the point of view of reliability. The research on detonation is being continued, and experiments are being made at the Royal Aircraft Establishment on a single-cylinder direct-injection engine for using heavy-oil fuel. An important feature of the year's work has been the arrangements made for co-operation with various universities and engineering colleges in the matter of engine research. A single-cylinder engine unit suitable for research work has been designed by Mr. H. R. Ricardo, who is a member of the Engine Sub-Committee of the Aeronautical Research Commitee, and these units have been supplied by the Air Ministry to Cambridge and Durham Universities. A universal test bed has also been supplied to the Manchester University, and all this equipment will be used for various researches under the direction of the Sub-Committee. The City and Guilds (Engineering) College also possesses a Ricardo set and will co-operate in any general plan of research.

Another Sub-Committee is entrusted with the investigation of accidents, and, as a result of their experiences, have come to the conclusion that the stoppage of the power plants is one of the most frequent initial causes of accidents to aeroplanes. Stoppages have been caused by broken pistons and cylinders, valve mechanisms, &c., but about 25 per cent. of those recorded were due to comparatively minor faults in the petrol system and a considerable proportion to defects in the ignition arrangements. The elimination, as far as possible, of such involuntary stoppages is thus a matter of primary importance both to the Royal Air Force and to the aerial transport firms, and, with this object in view, a recommendation has been made to the Air Ministry that a group of technicians should be appointed for the sole purpose of investigating the power plant stoppages which occur at the various Air Force stations. It is thought that this course would result not only in a reduction in the number of machines and engines written off on account of accidents, but would also direct attention to the more urgent problems and tend to assist in their early solution.

The prevention of fire, both in the air and after a crash, is obviously a matter of the utmost importance, especially in connection with the development of civil aerial transport, and is therefore a subject that falls well within the scope of the Committee's investigations. The Sub-Committee which deals with this branch of the work, has reported to the Air Ministry on the arrangement of petrol systems, pointing out that simplification of some of the systems in use would not only reduce the risk of fire but also render the power plant less liable to stoppage. In the case of certain multi-engined aircraft, it is suggested that simplification would result from the use of a gravity feed and a common collector box and also from the placing of the petrol pumps inside the tanks. The gravity-feed system is considered always to be preferable to any form of pressure feed, and the introduction of safety valves, or bursting discs, in all petrol tanks is also advocated. The fire risks and liability to stoppage arising from the use of petrol-resisting tubing and soldered joints in petrol pipes are said to be high, and there is some risk from the use of the newer form of tubing known as "Petroflex" in which the petrol-resisting material is gold-beaters' skin. All-metal pipe lines are therefore considered to be preferable to any other form of piping for the petrol-system. Experimental work is now in progress with the object of reducing the temperature of the exhaust pipe, and also to determine the correct size of safety vent pipes for petrol tanks. A light fireproof bulkhead has been designed and tested at the Royal Aircraft Establishment with satisfactory results.

Other branches of the Committee's work are concerned with meteorological problems and matters relating to aerial navigation, as well as with the properties of materials used in aircraft construction. Much experimental work has been carried out on the fatigue of metals, and some useful results have been obtained, although no complete explanation of the phenomenon has been arrived at. With the object of protecting aluminium from corrosion by the electro-deposition on it of other metals, some interesting work has been carried out at the Sheffield University with the co-operation of the Committee. Various metals, including cadmium, have been deposited and satisfactory adhesion has been obtained on curved surfaces. The use of cadmium in this way for the protection of aluminium carburettors, however, is not regarded as very promising, and, in the case of crankcases, a suitable paint has been found to be the most satisfactory protective medium. Further work on electro-deposition will be limited to an investigation of its effectiveness for protecting aluminium pistons coated first with cadmium and then with nickel. Light alloys, fabrics and dopes have also been investigated, but work on the two last-mentioned materials has been curtailed.

In the brief outline of the Committee's work which we have given above, it has not been possible to mention many of the investigations carried out. Even this short account, however, will serve as an indication of its character and scope and also to show that the Committee regard research work as something more than the mere acquisition of data.

BRITAIN AND JAPAN.

IN setting out to discuss the latest British Government Report on trading conditions in Japan, we wish to express our profound sympathy with the Japanese nation on the terrible disaster which occurred in Japan during the week-end and devastated by earthquake and fire a large tract of country over twenty miles in length and including great parts of Tokio and Yokohama. This sympathy is intensified by our close relationship with Japan, and particularly in shipbuilding and all branches of engineering. The Japanese have shown great courage in the development of these industries, and we have no doubt that the qualities which have brought them into a foremost place in the arts and sciences, will enable them to re-build their stricken cities and factories and recover their original or even improved condition. Before this catastrophe overtook them, they had almost reorganised society in Japan, bringing everything into line with the modern and Western civilisation.

Prior to the terrible earthquake and conflagration Japan was in a much better position than most countries of the world, as her trade was flourishing. Freedom from great fluctuations in the exchange and taxation which is truly moderate contributed towards the healthy state of her commerce. Unemployment returns were low and the few labour troubles were mostly confined to agricultural workers. It is true that some of the leaders of the Japanese financial and commercial world gave utterance to pessimistic opinions, but there seemed little cause for them unless it were the regrets at the non-continuance of the general rising markets of the prosperous times of war. How this state of affairs will be affected by the disaster it is too soon to inquire, so that we can only deal with the report before us giving a review of the conditions prevailing two or three months ago when it was written.

The most important of all the changes in this great market is the persistent demand for goods of the same type and quality sold in Europe. The Japanese market seems to have lost its eastern character altogether, and there is hardly a commodity which can be sold in Europe which does not find ready sale in Japan. Business missions of the representatives of particular industries from other countries have done much to strengthen the position of their trade, and there seems no doubt that the leaders of any British trade would be welcomed by the Japanese, and their visits would pave the way to a better understanding and increased activity. We read from a "Report on the Commercial, Industrial and Financial Situation in Japan for 1922-23," prepared by Sir E. T. F. Crowe, C.M.G., and Mr. H. A. F. Horne, of His Majesty's Embassy, Tokyo, that there is a great need for the visits to Japan at frequent intervals of British experts, and particularly of engineers. Americans are not slow at taking this course and many are reaping advantages from it. The British trade in textiles and textile machinery has been built up by able representation. The characteristic quality of the goods and the commercial soundness of the manufacturers are factors that have made the maintenance of the position not so difficult of accomplishment. Similar excellence is found, however, in other British manufactures produced by long-established and well-organised concerns, but in many cases they are not to be found in Japan in competition with articles made in other countries which are frequently inferior. What is hoped for in regard to the development of British trade in Japan is not a competitive scramble in fields which are to-day decidedly our own, but the prosecution of endeavours with those classes of goods where the British share is capable of large expansion. This is not impossible of attainment if a complete examination is made of the requirements.

The United States of America, the British Empire and China between them enjoy 82 per cent. of the trade of Japan, which is an even larger share than in former years. America takes 37 per cent. of the total, the British Empire 25 per cent. and China 20 per cent. The American position of supremacy is maintained through the Japanese exportation of raw silks and importation of cotton, and these account for two-thirds of her total business.

In the metal industry Britain has profited through the uncertainty of supplies from Germany, but our position in this market is far removed from our former pre-eminence. Some lost ground has been recovered, however, and a further extension is predicted for 1923. The recovery of the pre-war reputation for superiority of the block sheet manufactured in Britain has been made by the improvement of the material, and the Japanese are now eager to get the British product. It is thought that a larger proportion of this trade could be obtained if the sheets were given one pass through cold rolls before annealing. It is understood that this practice is common in America, although it adds to the cost, for the reason that it produces a smoother finish. In the tinplate market there is a shortage of stocks, and heavy demands may be anticipated during the remainder of the year. The material sought for is used for canning salmon and other foodstuffs, in the oil industry and in the manufacture of toys. India has become the largest supplier of pig-iron, and this activity is second only in value to her trade in raw cotton.

The great boom in building construction has abated somewhat recently, but many large structures which were started some time ago are being proceeded with. The reconstruction of the property destroyed will greatly intensify activity in this branch of industry. Quite 80 per cent. of the steel sections used in this work are imported from America, and the greater part of the balance comes from Germany. The roads of Japan do not favour motoring to the extent common in other countries, but there is much use made of cycles, and in this field Britain supplies one-half of the imported machines and 70 per cent. of the parts and accessories.

In the machinery market there has been very little variation in the total value of the importation during the last three years, but the American share is being gradually reduced. Of the total of 114,000,000 yen, textile machinery accounts for one-third, and of that sum about two-thirds is represented by imports from the United Kingdom. In the sphere of electrical machinery the Americans claim a very large share. The greatest participant in the machine tool market is America, while Britain is second and Germany third. The value of the total importation of these tools amounts to about ten million yen. Japanese producers of all types of machinery have presented a memorial to the Government urging an increase in the duties on machinery, but the consideration of keeping down production costs in the users' workshops is very important and it is hardly likely that any increase will be sanctioned.

There is much of interest to the engineering world in the report of Sir E. T. F. Crowe and Mr. Horne. It was recently published at 2*s.* net by the Department of Overseas Trade, and those manufacturers and traders who are not familiar with these reports or with the work of the Department could not do better than study this report on Japan as a good representative of the series.

RADIO-TELEGRAPHIC DIRECTION-FINDING BY RECEPTION.

THE various systems of radio-telegraphic direction-finding in use at the present time—the single frame coil, Bellini-Tosi and Robinson—are distinct in type but similar in principle, and it is important to know how far this similarity makes results obtained with one applicable to the others. For some time past a Committee of the Radio Research Board, set up by the Department of Scientific and Industrial Research, has been engaged in investigating various methods used in directional wireless, and as a preliminary to the publication of the full data obtained on variations of bearing of fixed stations the Department has now published an account of observations made for the Committee on the three practical types of systems of direction-finding by reception.*

Before setting out their actual observations the authors give a simple theory of these systems, leading to the conclusion that substantially they are identical in principle, and that when each is used to its best instrumental and operative advantage they must give identical results with any given type of wave front and set of circumstances. Each of them turns on the fact that the magnitude of the E.M.F. induced in a vertical loop by an arriving electromagnetic wave depends on the angle between the magnetic field and the loop, and the assumption that the horizontal components of the field and of the direction of motion of the wave are at right angles, as they commonly are. Accordingly the apparent direction is observed on each system by rotating a loop or some equivalent element round a vertical axis until the position is determined in which the signal E.M.F. is zero or at least a minimum.

The form of the relation between the E.M.F. in the loop and the angle that it makes with the magnetic field is seen most simply by considering a single-turn vertical plane conducting loop of any shape, pivoted about a vertical axis, and exposed to the electro-magnetic field of an advancing wave. The wave front is assumed to be sensibly plane, and may be inclined at any angle to the earth's surface, the magnetic field lying in any direction in the wave front. The loop lying in a vertical plane, the vertical component of the passing magnetic field cannot link with it, and the effect of the field on the loop will be measured therefore by its horizontal component. If the wave length be large compared with the dimensions of the loop the maximum E.M.F. induced in the loop will then be the cosine of the complement of the angle between the plane of the loop and the horizontal component of the field, multiplied by the product of the maximum value of that component, the periodicity of the waves and the area of the loop. When therefore the loop is rotated into a position in which the complement is 90 deg., so that the plane of the loop is the same as the vertical plane containing the direction of the magnetic field in the wave front, and on the assumption mentioned above is accordingly perpendicular to the vertical plane containing the direction of travel of the waves, the E.M.F. will be zero. The form of the equation is thus $E_m = K A \cos a$, where E_m is the maximum E.M.F., A is the area of the loop, and K is the product of the periodicity corresponding to the waves and the maximum value of the field.

The single coil system is closely similar to the single-turn loop. Its chief differences are that it has several turns instead of a single turn, which do not necessarily lie in the same plane, and that a tuning condenser and detecting apparatus are connected in the circuit. If the extra space occupied by the extra turns could be neglected, the E.M.F. induced in the coil would be the same as with the single-turn loop multiplied by the number of turns in the coil, *i.e.*, K P cos *a*, where P is the product of the sectional area of the coil and the number of turns; and if the coil is wound spirally in the same plane (pancake winding), this becomes its actual value if the effective or mean area of the coil is substituted in this expression for the sectional area. When the coil is wound spirally in a series of equally dimensioned loops in nearly parallel planes (box winding), and the planes are inclined constantly to the axis of the coil, the inclination of the wire will add to the area which is a factor of the E.M.F. an amount equivalent to what would be caused by half the cross-sectional area of the coil, acting in a plane at right angles to the main coil; and by a simple trigonometrical transformation the equation for the single-turn loop when applied to the coil takes the form

$$E_m = K P' \cos (a + \delta),$$

where $P' = \sqrt{P^2 + \left(\frac{A'}{2}\right)^2}$, $\delta = \tan^{-1} \frac{A}{2P}$, and A' is the cross-sectional area of the coil. This means in effect that a box-wound coil of the type described is equivalent in directional properties to a single-turn loop with its plane at a fixed angle δ to that of the mean or effective plane of the true coil and with area × turns $= \sqrt{P^2 + \left(\frac{A'}{2}\right)^2}$. In most cases, however, the authors find that the error involved in taking the E.M.F. at the value K P cos *a*, found for the hypothetical coil in which the cross-sectional area is neglected, is of no practical consequence. In their experiments, for example, with a typical box coil the angle δ worked out at 0·1 deg.; and they suggest that if later developments make it desirable to eliminate even errors of this order of magnitude, the addition to the hypothetical value K P cos *a* can be avoided by winding the coil in accurately parallel planes and making the connections between the turns at the top of the coil practically parallel to its axis. In any case, however, the error appears to be of a lower order than others affecting the authors' experiments, which accordingly have no direct bearing on this part of their theory.

The usual practice in using a single coil system for determining direction is to introduce a variable condenser across the ends of the coil, adjusting it to give resonance to the incoming waves, and to use the resulting alternating potential difference across the condenser to operate a detecting amplifier arrangement so as to give audible response to the

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waves. The effective resistance of the loop depends not only on its dimensions and the frequency employed, but also on the nature and circuit of the detecting arrangements; but in any case the current in the loop arising out of the induced E.M.F. ($E_m = K P \cos \alpha$) will be that value divided by the effective resistance of the loop $\left(I_m = \frac{K P \cos \alpha}{R}\right)$ and the potential difference across the condenser resulting from this current will be its value divided by the product of the periodicity and the capacity of the condenser at resonance, which simplifies into $V_m = \frac{H_m P \cos \alpha}{R C}$, a quantity which evidently varies with the orientation of the coil in precisely the same way as the induced E.M.F. The usual detecting apparatus used with a single coil, a combined amplifying-detecting arrangement of triodes, may pick up in itself and the leads a small E.M.F. from the incoming waves, which will be independent of the orientation of the coil, and may give a loud enough signal when the main E.M.F. is at or about its zero to blur the zero reading into a more or less ill-defined minimum, and so reduce the accuracy with which the bearing can be read. A further disturbance may arise through vertical capacity currents that the capacity to earth of the valve apparatus connected across the condenser will cause to flow to earth from the two vertical sides of the coil. These currents will usually be unequal, by reason of the capacity to earth of the grid of the first valve being much smaller than that of the filament with its associated batteries, and a P.D. will thus arise across the condenser even when there is no circulating current in the coil itself. The phases of these currents will vary through inductance of the vertical sides of the loop and their capacity to earth, the P.D. across the condenser will in general be in quadrature with that produced by the circulating currents and so blur the zero reading, and the non-directional character of the superimposed P.D. will make the minima on a rotating coil not exactly 180 deg. apart. These disturbances, arising from vertical or "antenna" currents, appear to be successfully avoided by using a compensating condenser connected between the grid of the first valve and earth to equalise the two capacities, so equalising the two "antenna" currents and avoiding the production of a resultant P.D. across the tuning condenser.

In the Bellini-Tosi system two large exactly similar loops, usually single-turn and of rectangular or triangular shape, are erected with their planes accurately at right angles. These loops are far too large to be rotated in operation, and each is therefore connected in series with a small field coil, the two field coils being also mounted with their planes at right angles, and preferably parallel to the planes of their respective loops. A small search coil is pivoted so as to rotate within the field coils, and its axis carries a pointer which moves across a horizontal circular scale. This arrangement thus reproduces the single-turn loop discussed above, and the magnetic field of advancing waves produces in the loops maximum E.M.F.'s of which the horizontal components are equal to $K A \cos \alpha$ and $K A \sin \alpha$, to which the magnetic fields produced by the two field coils in the direction of their axes are respectively proportional. Assuming, therefore, that the search coil is so small that the field is sensibly uniform over its area, the resultant of the fields produced by the field coils will be proportional to that of the main field in which the two loops are situated, and will make with the axis of either field coil the same angle as the main field makes with the corresponding loop. The search coil turning within the field coils and forming with them a "radiogoniometer," is accordingly equivalent, theoretically, to a rotating single-turn loop. It can be used similarly for direction-finding, and its practical differences, such as a certain amount of the "antenna" effect noticed with the single coil, are only of secondary importance.

In the Robinson system two coils are fixed rigidly at right angles, pivoted about a vertical axis, and connected in series with a reversing switch in circuit. If the horizontal component of the field makes an angle (90 deg. $- \beta$) with the effective plane of one coil, and there is no mutual induction between the two coils, the E.M.F. set up in the coils, if they were separate, would be $\omega H_m . P \cos \beta$ and $\omega H_m . Q \sin \beta$, where ω is the periodicity corresponding to the waves, H_m the horizontal component of the field, and P and Q the sectional area $\times$ number of turns in the respective coils. As the coils are not separate but in series, the resultant E.M.F. in the circuit is the sum or difference of these expressions, according to the position of the reversing switch; and by introducing the angle $\tan^{-1} \frac{P}{Q} = \phi$ and applying simple trigonometrical transformations the E.M.F. can be expressed in the same form as was obtained for the single coil arrangement, the angle α being then the sum or difference $\beta \pm \phi$, which is thus increased or diminished by 2ϕ when the switch is reversed. If, therefore, the whole system is rotated till the signal strength is equal in both positions of the switch, the extreme positions of the system will be symmetrical about the position of maximum or minimum E.M.F. so that one coil must lie with its plane parallel to the horizontal component of the field, which is normal to the direction of travel of the waves. The ratio $\frac{P}{Q}$ is so chosen in the design of the coil as to give the most suitable value for the "swing" (2ϕ).

In each system, accordingly, the theory outlined above shows that the method is substantially equivalent to the use of a single-turn loop. For the assumption that the horizontal components of the wave direction and the magnetic field are at right angles to be true either may be at any angle provided the other is horizontal; but if neither is horizontal, the setting of the coil in its minimum position will have no necessary relation to the direction of arrival of the waves nor to the horizontal component of that direction, so that errors will result.

The practical observations were made in three separate sets. The first set was made at the Slough Research Station of the Radio Research Board over a period of about three months, during which for several hours on several days in each week the bearings of 9 transmitting stations, mostly in various parts of Europe, were taken as nearly as possible simultaneously on Robinson and Bellini-Tosi sets. These stations were fairly well spaced round the compass, with the exception of the N.W. quadrant, in which few observations were made, and night and day periods were worked in about equal numbers. The Robinson set had coils 5 ft. by 3 ft., wound with 30 turns, and 3 ft. by 2 ft. 10 in., wound with 12 turns. A combined tuner-switch box was mounted on the stand carrying the rotating systems, and leads from it were taken to a seven-valve combined amplifier-detector, which, with its batteries, was set up several feet away from the coil to eliminate any induction error. The Bellini-Tosi set was of the portable land station type, as formerly used by the army, with triangular loops of 65 ft. base and 40 ft. height and a 50 ft. centre mast. The loops were untuned, earthed at their common centre point, and used with tight coupled radiogoniometer and high frequency transformer, constructed with an earthed metallic shield between primary and secondary. Both sets were situated in a space clear of trees and other obstacles, and were about 100 yards apart, so that mutual interference was negligible. The range of wavelengths received was from 2 km. to 5 km. Eight stations used genuine spark transmitters; the ninth (Horsea) used a continuous-wave transmitter, as did another station (Nauen) by night, these being observable on a spark receiver by reason of fluctuations in amplitude of wave.

The signal strength on both sets was practically the same, no station being within range of one set and yet too weak for the other. With very few discrepant results the readings of the two sets were very close to each other, even when, as at night, they showed relatively large variable errors from the true bearing. For day readings the means of readings by the two sets on the same stations differed from 0 deg. to 2·4 deg., the standard deviations by 0·1 deg. to 1·0 deg., with a slight advantage to the Robinson set, and the permanent error for these observations, *i.e.*, the difference between the mean observed bearing for the period and the true bearing, varied between 0·1 deg. and $-$ 1·5 deg. for the Robinson, and between 0·1 deg. and 2·2 deg. for the Bellini-Tosi. Though the differences were thus of the same order, they were sometimes of opposite sign, and further experiments are to be made to discover whether this discrepancy is due to difference in instrumental errors or to the slight difference of the two systems in local surroundings. The extreme bearings in these readings varied from 0·4 deg. to 2·4 deg. with the Robinson set and from 1·0 deg. to 3·0 deg with the Bellini-Tosi, but on the night observations they were from 1·8 deg. to 27·1 deg., with the Robinson, and from 3·5 deg. to 28·0 deg with the Bellini-Tosi. The standard deviations by night differed by from 0·1 deg. to 2·7 deg., and curves are given for particular periods showing close concordance between the variations of the two systems in the presence of wide differences between the actual readings of each of them. The disturbances found at night often blur, or sometimes, according to later observations, appear actually to obliterate the minima, and the report suggests that the few serious discrepancies can easily be explained by the obvious difficulty of getting accurate readings from very broad and ill-defined minima.

The second set of observations, also made at Slough, extended to all three systems. The single frame coil was a collapsible wooden frame, 3 ft. 4 in. square, wound with two separate coils each of 16 turns, which for different wave-length ranges could be connected in series or parallel by means of a switch. Variable and fixed tuning condensers were provided, together with a compensating condenser for obtaining sharper minima as explained above. By adjusting this condenser for each change in wave-length of the coil system very sharp zeros were obtained, and bearings could be read to 0·1 deg. A six-valve screened amplifier-detector was used for reception. A separately screened oscillator enabled observations to be made on continuous waves. The same Bellini-Tosi set was used as in the previous experiment, together with a separately screened oscillator for continuous wave direction-finding. The Robinson set had two coils about 4 ft. square, wound respectively with 32 turns and 12 turns in four sections, which could be connected in series or parallel for different wave-length ranges. A metallic screening box was provided for the oscillator, amplifier and batteries to enable c.w. reception to be carried out. The absence of mutual interference between the sets was verified by tests. Some 550 observations were taken over a period of one month, 50 of them by night; each bearing was taken simultaneously on either all or two of the sets.

Eleven transmitting stations were observed, 10 of which sent continuous waves. Wave-lengths varied from 1·8 km. to 9 km. By day the readings on each receiving set were closely concordant. The extreme variation from the mean found on any set was 2·4 deg., and on about half the stations was under 1 deg. The standard deviations varied between the three sets by not more than 0·5 deg. and mostly by less, and the permanent errors for the period of the observations varied from $-$2·0 deg. to + 1·3 deg. for the Robinson, from 2·1 —deg. to + 3·2 deg. for the Bellini-Tosi, and from $-$1·5 deg. to + 2·7 deg. for the single coil. By night the greatest deviation from the day mean recorded on any set was 5·4 deg. In some readings there was notable agreement between the three sets, though appreciable differences occurred in others; and in at least one instance the minima were too broad to allow a bearing to be taken.

The third set of observations was taken at H.M. W.T. Station at Orford in Suffolk. For the Bellini-Tosi set, which is erected permanently at this station, the aerials are of approximately diamond shape, supported on a central mast 92 ft. high, with corner masts 32 ft. high. The apparatus was arranged with a suitable intermediate circuit for receiving on the wave-length range 2·0 km. to 9·0 km., using untuned aerials and a tight-coupled goniometer. A six-valve amplifier was employed, to which was coupled a separate screened oscillator for c.w. reception. The same Robinson set was used as in the first set of observations, with a screened oscillator for c.w. reception. The hut containing this set was 380 ft. from the central Bellini-Tosi mast, and tests showed that there was no mutual interference between the two sets. Observations were made for 3½ hours to 4 hours per day over a

period of five weeks, 2,185 readings being taken. As in the previous experiments, all bearings were taken simultaneously on both sets on 19 transmitting stations, several sending two or more different wave-lengths. Of these, 15 sent only continuous waves, four had only spark transmitters, two had both systems, and eight additional wave-lengths were also sent from various stations.

In most of these observations the mean day bearings on both sets were correct to within a fraction of a degree, and although occasionally variations as high as 7·5 deg. were obtained on the Bellini-Tosi set and 3·7 deg. on the Robinson, variations of more than 2 deg. were rare on either set. The wider discrepancies in the Bellini-Tosi set may be due to errors of observation, which can readily occur when taking quick swings over large angles. The smaller variations of from 1 deg. to 2 deg. on either side of the mean are in the authors' opinion definite day variations, occurring as they do simultaneously on two independent sets. The night variations reached as much as 54 deg. on the Bellini-Tosi and 53 deg. on the Robinson, but the variations and systematic errors of the means were much the same for both sets, and curves are given showing that readings on the two sets kept closely together in the face of very wide variations in each of them. The strength of signals was as great on the Robinson as on the Bellini-Tosi set, using the same amplifying apparatus, nor did interchange of observers produce any difference.

The net conclusion from the experiments is that for the wave-length ranges observed, all three systems examined show substantially the same effect from whatever disturbances may be present, and that the observations are consistent with the theory and conclusion set out in the earlier part of the report. Contrary to what has sometimes been suggested, extra size of loop appears to afford no additional security against night errors. The Bellini-Tosi and single frame sets gave sharper zeros with heterodyned undamped waves than with damped waves, owing to the greater sensitivity of a detector to undamped waves. In spite of this increased sensitivity, the Robinson set gave a lower accuracy in receiving continuous waves than spark signals, though even with them observations could be made to an accuracy well within 1 deg. Each of the three systems has nevertheless its own advantages in construction and operation, some details of which are given.

THE STAMPED OR PRESSED METAL WARES TRADE BOARD INQUIRY.

SIR WILLIAM MACKENZIE, in his report concerning the proposed scope of the Stamped or Pressed Metal Wares Trade Board, which has been published within the last few days by the Stationery Office, has laid down important principles which, if given effect to by the Ministry of Labour, will probably relieve many engineering employers of a great deal of the embarrassment which the Stamped or Pressed Metal Wares Trade Board has occasioned them in the past.

This Trade Board was created in 1919, and, as Sir William indicates, its scope has been in debate since 1920. In the spring of this year the Minister of Labour issued the draft of a special order which he proposed to make, defining anew the scope of the Board. Objections to this were lodged on behalf of a number of employers and employers' associations and of one trade union, and Sir William Mackenzie was appointed by the Minister of Labour to hold a public inquiry into the matter. The inquiry lasted four days, and the report is the result.

In the draft order the Minister proposed to bring under the jurisdiction of the Trade Board the manufacture from metals in sheet or strip form by the processes of cold stamping or cold pressing of any of the articles or any parts of the articles specified in a long schedule. These included cabinet fittings, door fittings, light fittings (such as electroliers, pendants and standards for electric or gas light) bag fittings, umbrella fittings, bedstead and fender mounts, smokers' sundries, stationers' sundries, cycle or motor cycle accessories, and many miscellaneous articles. It was contended by a number of the objectors that this was not one trade but included parts of many trades, and that the Minister had no power to bring it all under the Stamped or Pressed Metal Wares Trade Board. The evidence showed the impossibility of giving effect to the Minister's proposals; and the Engineering and the National Employers' Federations contended that where a manufacturer made a composite article, such as, for example, an electrolier, a dynamo for motor cycle lighting, or an umbrella frame, the mere fact that some of the component parts were manufactured by the process of stamping or pressing should not bring the manufacture within the scope of the Trade Board.

Sir William Mackenzie appears to have given effect to this contention. He says: "The essence of trade is to sell or exchange, and where a person manufactures an article and sells or exchanges it, he is carrying on a trade. Where, therefore, a person manufactures stamped or pressed metal articles and sells or exchanges them, he is carrying on the trade of a manufacturer of stamped or pressed metal wares"; but "where a manufacturer makes or sells stampings or pressings as a small portion of, and incorporates them in, the finished product which he manufactures and sells as a finished product, he is not carrying on the trade of stamping and pressing but the trade of manufacturer of the finished product." Sir William states the general rule thus: "Where the operations of stamping and pressing are carried on by a manufacturer merely incidentally to the main or major operation of the completed manufactured product of the establishment, and where there is only a small section of the stamped or pressed goods embodied in the completed product, the manufacture of the completed product does not belong to the Stamped or Pressed Metal Wares Trade." He illustrates this by reference to the manufacture of bedsteads with which are incorporated stamped or pressed bedstead mounts. He says the manufacturer of a dynamo for motor cycle lighting may manufacture and make use of a small section of stamped or pressed work for the completion of the dynamo, but this is merely incidental, and the stamp or pressed work is part of the operation of the manufacture of the completed article, the dynamo. He refers in the same way to the manufacture of umbrella frames, cast iron hollow-ware, electric light fittings, pillion saddles for motor cycles, and other articles, in all of which a varying amount of stamped or pressed metal work may be incorporated. "On the other hand," writes Sir William, "in so far as a manufacturer places his stamped or pressed metal wares on the market in competition with the general stamper or presser, he is engaged in the stamped or pressed metal wares trade. If, for example, the manufacturer of the bedstead or fender or umbrella frame does not confine his production of bedstead mounts or fender mounts or umbrella furniture to such articles as he himself utilises in making up the bedsteads or fenders or frames, but, in addition, trades in such articles in the open market, or uses his plant for the making of other stamped or pressed metal articles, which he sells as such, he is to that extent engaged in the general stamped or pressed metal wares trade."

A further class which Sir William would include within the trade is the manufacturer of a composite article whose operations of stamping and pressing comprise the main manufacturing operations, and where only a small section of other goods is embodied in the completed product. In certain other cases the finished product of manufacture may be on the border line of the trade.

Having laid down these general principles, Sir William recommends that the draft order should be revised and confined to the stamped or pressed metal wares trade in conformity with his view of the limitations of that trade. This, if given effect to by the Ministry, will mean that the activities of the Trade Board will be confined to those manufacturers who manufacture and sell stampings and pressings as such; while manufacturers in whose completed products there is only a minor amount of stamped or pressed work will be free from interference by the Board. The Report, we imagine, is likely to revolutionise the Ministry's conception of the proper scope of the Trade Board, but the revolution will be welcomed by engineering employers generally.

THE INSTITUTION OF NAVAL ARCHITECTS IN HOLLAND.

ON arrival at Flushing on Saturday evening, September 1, after a very pleasant crossing, the party of two hundred visiting Holland for the Summer Meeting of the Institution of Naval Architects were entertained to dinner in the Grand Hotel by the Reception Committee. Dr. A. G. Kröller, President of the National Committee of the Nautical Institution and Museum, who presided, spoke of the pleasure it gave them all that the meetings were being held on Dutch shores.

His Grace the Duke of Northumberland thanked the chairman and his committee on behalf of the members, for the very cordial welcome they were given on their arrival in the ancient and historical country of Holland. It was an additional pleasure that their visit coincided with great national rejoicings.

On Sunday the party were conveyed by motor cars through the cities of Middelburg, Veere and Dornburg. The occasion was made a memorable one by the wonderful singing of a village choir at Dornburg.

INTRODUCTORY PROCEEDINGS: A WELCOME.

The first meeting for the consideration of papers was held in the Grand Hotel at Flushing on Monday morning, September 3. The Duke of Northumberland presided and was supported on the platform by Mr. J. A. Lambrechtsen, President of the Shipbuilding Section of the Royal Institute of Engineers, and Professor S. G. Everts, President of the Institute.

The Duke of Northumberland, in opening the proceedings, referred to the representative character of their programme; the papers submitted for consideration would cover all the most urgent problems in shipbuilding, and contributions would be made by scientific authorities from Great Britain, Holland and Italy. His Grace made further reference to the hospitality of the Reception Committee and was satisfied that the meeting would stand out as one of the most successful of all. The papers that would be read were of a great value in the furtherance of scientific work, but their significance in bringing together the people of different countries who are interested in the same problems was of more importance. The mutual pooling of opinions and experience was of great service in making possible the appreciation of the views and mentalities of others. In conclusion, he read a telegram despatched to the Queen of the Netherlands expressing the congratulations of the Institution of Naval Architects on the twenty-fifth anniversary of her ascension to the Throne.

Mr. J. A. Lambrechtsen was asked to address the meeting, and in a few words he expressed the formal welcome to the visitors of the Dutch institutions. He emphasised the value of interchanging knowledge, experience and practice. Time spent in that way was never wasted.

Mr. R. W. Dana, after making a number of announcements regarding the arrangements, added his own personal testimony to the excellence of the arrangements made and gave great credit to Baron van Haersolte.

WATER-TIGHT SUB-DIVISION OF SHIPS.

The chairman then called upon Sir Archibald Denny, Bart., LL.D., to read his paper on "Notes on the Curves and Formulæ for Regulating the Watertight Sub-division of Passenger Ships." The paper as originally printed is reproduced on page 314 but the author intimated some corrections at the meeting, the most important of which was in the Appendix B. "Extract from the proposed new Article VIII," Convention Regulations. The changes were made in view of very recent investigations and had for their purpose the elimination of any reference to the length of any compartment forward of the machinery space, or of the aftermost compartment exceeding the floodable length in ships of the classes referred to in the third and fourth last paragraphs (sub-sections ii and iii).

Mr. A. C. F. Henderson then read his paper on "The Sub-division of Large Passenger Steamers," giving views from the shipowners' standpoint. The paper is reprinted on page 317 of this issue. The discussion on these two papers was then opened by

Sir Westcott Abell, who stated that the two papers represented two distinctive points of view which it had been their aim to bring into harmonious relationship. Physical requirements of sub-division might clash with the requirements based on the economic limitations of running conditions. With theoretical considerations pushed forward to an undue extent ships would not be built, and passengers might be forced to travel in worse protected ships than if the regulations were not so drastic. Compromise represented as good a solution as any other, with the present state of knowledge. He thought the numerical definitions of the passenger function of a vessel as contained in the proposed "criterion of service" was a distinct step forward in the study of a very involved question. Sir Archibald Denny seemed to imply in one part of his paper that there was a decided preference for grading the severity of subdivision in a gradual and continuous way in contrast to the statement "it is to be noted that the German system was a series of steps." That seemed a contradiction in terms. It was impossible to see how any progression of the kind could proceed in a gradual way. If the minumum number of bulkheads for a particular ship had been determined on the basis of the regulations, it followed that any increase in length on that meant that one more bulkhead must be used. The whole scheme was thereby changed. That meant that there must be change in a series of steps rather than a smooth curve.

The second fundamental point was that the uniform grading of the severity of sub-division was only uniform as long as the bulkheads remained intact, and the factorial system as at present applied failed when damage occurred in such a manner as to destroy the integrity of the bulkhead. A ship was as likely to be struck at a bulkhead as elsewhere, and consequently the factorial system might indicate the necessity for a further bulkhead but that would mean a greater margin if the bulkhead were cut. The third point which demanded elucidation had reference to the permeability assumed for the determination of the bulkhead spacing. It was clear that rarely, if ever, during the ship's lifetime did the actual conditions comply with the assumptions. There was considerable ambiguity in that side of the sub-division problem.

Any solution was very empirical and it was simpler, and at least as effective, to consider the matter from that standpoint. Zones might be drawn on the subdivision diagram showing the conditions under which any given number of bulkheads was required. The same argument supported Mr. Henderson's contention that a good two-compartment standard with a margin for contingencies was at least as efficacious as a hypothetical three-compartment requirement. When the proposed curves were taken, and the factor of sub-division multiplied by the corresponding length, the product was nearly constant. It followed that for geometrically similar ships the spacing of main bulkheads was practically constant no matter what the length was. That was tantamount to what the classification societies said—that the number of bulkheads for a cargo vessel was approximately the length divided by a constant quantity.

Mr. W. J. Luke looked with great sympathy on any effort to discover a "criterion of service," a figure for permeability or any other empirical coefficient necessary for practical purposes and which would meet with approval. The keynote of Mr. Henderson's paper was that a two-compartment standard of subdivision was quite sufficient for practical purposes and that was the opinion he (the speaker) had independently arrived at. The International Convention laid down two salient points: that a measure of safety exceeding the two-compartment standard was necessary for all passenger vessels of over 500 ft. length and reaching the three-compartment standard at 900 ft., and that the length of an individual compartment should not exceed 92 ft. The desirability of the two-compartment standard required no argument. We should congratulate the Board of Trade in having even informally reconstituted the Bulkhead Committee within ten years of its formation. With its continued operation obsolete methods would not become stereotyped and the Government Department concerned would keep in the forefront of progress.

Professor E. Vosnack, of the University of Delft, testified to the importance of the work done in connection with subdivision in Britain and the modification of the regulations where necessary. Sir Archibald Denny had surveyed the stages in the progress in a very complete and interesting way. As one of the Dutch representatives on the International Conference on Safety of Life at Sea in 1913, the speaker was interested in that evolution and had checked the requirements of the convention and the Board of Trade in the cases of old and new vessels. Practically all foreign built passenger ships for use in Dutch waters were in accord with those requirements. The demands of safety made increased provision with increased length imperative and the changes must be gradual and continuous. Sir Archibald had remembered the fact that the convention had practically accepted the standards of severity of sub-division of the German rules. Those gave increases in steps as the length was made greater. He looked forward with hope to the time when international agreement would be possible.

Mr. J. Foster King spoke as a member of the informal committee and said he thought their work was making for simplicity and ease of application. Political interests hampered the free treatment of the question and only within the limits they prescribed was any change possible. The issue must be decided by the methods of objection rather than subjective analysis. Any form of arbitrary system must go by the board if the decisions based upon it did not fit in with economic necessities.

Mr. John Anderson thought that the factorial system was to be preferred as the practical way of approaching the subject in a detailed fashion. At the same time nothing should be adopted which would impose penalties on the shipowner. Simplicity must be aimed at and all complications connected with change of form eliminated. It must not be forgotten that the changes in permeability which one was liable to get were more than covered by the corrections due to change of form.

Professor Percy Hillhouse thought that no one would deny that the 1912–15 Committee founded a well laid scheme but, on occasion it was, like all such, proved wanting. He would welcome any method by which arrangements could be got at quickly. Days were lost getting out drawings which could be saved if a reasonably simple scheme was acceptable. They needed to get back to Lloyd's early rule in an improved form. He (the speaker) thought that it might be possible to frame a scheme based on the principal dimensions, speed, block coefficient with a factor to cover the differences due to cargo or passenger working, by means of which the spacing could be settled right away. In practice Lloyd's rule proved fairly satisfactory. He did not favour any complicated methods based on assumed conditions.

Mr. A. T. Wall suggested that a change towards simplification was imperative. In the present stage of development it was unnecessary to go into details. All that was required was the establishment of broad principles. Exact mathematical analysis was impossible and everything pointed to the solution being found along general lines. For ten years the matter had been under consideration but no national, let alone international, agreement had been reached as yet. The basis on which the results were framed should be given in every case when statements were made that a certain standard of subdivision had been obtained in a ship. The assumptions used in arriving at the factor should not be omitted. That was, however, not all that was required as differing arrangements of bulkheads, which affected the factor, would give quite different degrees of safety for any assumed length of damage. Mr. Henderson, the speaker said, had shown that very clearly in his paper, and they were indebted to him for the examples he had cited. General rules had the obvious advantage of not imposing economic restrictions and could be made to give as good a degree of safety as any complicated system. He advocated a scheme in which the number of bulkheads was based on the length but with the addition of some allowance to cover the effects of class of service. Maximum and minimum restrictions on the spacing of bulkheads would also be necessary. Apart from those, practical considerations would keep the spacing within reasonable limits.

The fact that there were other factors than bulkhead spacing which affected the safety of a ship at sea was emphasised by Mr. Henry Napier, who thought that they must take care that they did not put too much stress on the bulkhead question.

Sir Archibald Denny, in reply, said that he had aimed at giving an account of the work of the convention and the reasons which dictated their decisions. In putting these matters and those relating to the informal committee, he was pleased that all agreed that the work done by those bodies was of service. In his, the speaker's, opinion, the factorial system was valuable in the grading of the severity of subdivision. He answered the criticism regarding calculations by stating that the Board of Trade officials had with their experience been able to reduce the time involved and make the work of a simple type. The papers might be thought to have been very different in character, but it was the case that there was much in them in which agreement was shown. In a reference to the diagram (Fig. 1, page 315) Sir Archibald pointed out that it depended on the level of the water line whether the damaged ship would remain upright or have a list. The danger of capsizing might be greater than that of sinking. It was advisable that each nation should follow the example of Professor Vosnack and test the rules and recommendations.

Mr. A. C. F. Henderson stated that the shipowners appreciated all that the Committee had done in the attempt to devise a reliable and safe scheme that would be satisfactory to all nations. That work should be continued and it was the view of the shipowners that possibly a more simple and workable scheme would be found which would be welcomed by all.

The Duke of Northumberland thanked the authors for bringing together for discussion the views of builder and owner.

Dutch River Lighters.

The third paper taken was one by Mr. A. M. Schippers on "Dutch River Lighters." It is reprinted on page 311.

Sir John E. Thornycroft opened the discussion and expressed the thanks of the Institution for a valuable contribution on a subject in which the Dutch shipbuilders greatly excelled. He had examined the types of boats described and was greatly taken with their construction and riveting. The passing of the wooden lighter was to be regretted when considered from an æsthetic point of view, but the skill of the Dutch builder had made possible the imitation of the old form in steel.

Mr. George S. Baker welcomed the paper as filling a gap in the literature of naval architecture in the proceedings. Information on the coefficient of displacement for the different ships would be of value. The comparison of the rudders of Dutch and English lighters showed great differences. Were they due to difference in the dimensions or to the greater skill of the Dutch navigators? In England straight framed boats had been built which gave quite as satisfactory results as those of the ordinary ship's shape. The speaker referred to the account of the Missisippi Commission 1912, of Professor Sadler, in which particulars of train boats as well as single ships are given.

Sir Archibald Denny asked for information if difficulties had been experienced in launching such long boats.

Mr. A. M. Schippers, in reply, said that he would be happy to give the figures and particulars asked for. No difficulties had been experienced with the launching of the vessels.

This ended the proceedings at Monday's meeting.

(To be continued.)

Messrs. Richard Johnson, Clapham and Morris, Limited.—This well-known Manchester firm has issued an historical booklet dealing briefly with its development during the last 150 years, since 1773, the date of foundation of a pin manufactory, wirework and wire-weaving business, in Market Sted-lane, Manchester. The firm now owns works, branches and warehouses in a number of cities in England, Australia and New Zealand and has a world-wide reputation.

NOTES.

FRENCH NAVAL AIRCRAFT.

ACCORDING to the French journal, *Le Moniteur de la Flotte*, the budget for naval aeronautics for 1923 has now been settled by Parliament, the total sum to be expended being, in round figures, 105,500,000 fr. The total for 1922 was 37,000,000 fr. only; from one year to the other, therefore, the grant has almost trebled. Since the total credits for the Navy have increased but slightly (1,028,000,000 fr. in 1923, as against 977,000,000 in 1922), it will be seen that the position occupied by aeronautics in the Navy has become relatively more important; aeronautics, in 1922, accounted in the budget for only 3·8 per cent. of the total; now the proportion is over 10 per cent. The proportion is about the same in the budget for the War Department, namely, 380,000,000 fr. in a total of 3,500,000,000 fr. The total expenditure allowed for naval aeronautics is divided into two classes, one, for which 57,000,000 fr. are allowed, for maintenance purposes, the balance, 48,000,000 fr., being apportioned to new work. It will be seen that the expenditure for maintenance is much higher than the total naval aeronautics budget of last year; this is due to the exhaustion of the stores from which the service has been able to draw until now. The section for new work comprises the purchase and construction of machines and the installation of bases. Three squadrons of 18 machines, or 54 machines, will be purchased, the structures to cost 7,200,000 fr., the engines 7,700,000 fr. and the spare parts and armament 4,700,000. For the machines to be built at the commencement of next year engines to the amount of 9,100,000 fr. are to be ordered immediately, of which 8,800,000 fr. are to be expended during the present year. The total expenditure for the present year is therefore 28,400,000 fr. The expenditure on aeronautical bases is to amount to 19,500,000 fr. Besides the above, the Minister of Marine is authorised to order in the present year aeronautical material to the amount of 13,000,000 fr. in anticipation of the credits which are to be granted for the following year.

IRON CASTINGS.

The difficulties which surround the making of a sound iron casting are emphasised in a note upon cast iron for marine engine castings from the metallurgical and engineering points of view, read yesterday by Messrs. H. J. Young and E. Wood, before the Institute of Marine Engineers. The progress made in the manufacture of steel and non-ferrous metals, which have received the special attention of metallurgists and scientists, seems to have been accompanied by some neglect of the possibilities attendant upon cast iron. For this reason we always welcome a contribution to any technical society dealing with this latter and comparatively older metal. The note we refer to calls attention to the involved conditions which may be said to beset the manufacture of a perfectly reliable iron casting, and suggests that matters would be improved by directing to cast iron the same amount of work that has been given to steel. The authors advocate more research work. They are of opinion that progress in the production of satisfactory iron castings can only be made, by more study of macro—and micro—structures, and yet they give an illustrated example in which it has been impossible to detect any difference between the structure of the "drawn" or bad part of a cast iron piece and that of the good portion. This affords an example of the points which have to be cleared up before research work can proceed on satisfactory lines. The authors lay stress, and very rightly so, upon the active co-operation required between the engineer, the designer, the chemist and the foundryman for the production of good iron castings in ordinary everyday practice. They show, as an illustration, how a very small coring out of a rib at the junction of two main surfaces, as in a tee piece, a stop valve or a steam cylinder, can make for a good job, as compared with other instances where such a coring out has not been effected. So far, the making of good iron castings would appear to depend very largely upon the experience of the foundryman; this is also the case, to a great extent, in regard to steel and non-ferrous castings. The authors' statement to the effect that it appears easier to produce standard cast iron from the cupola than from other furnaces, including the electric furnace, is rather surprising, and is probably due, as they suggest, to the fact that those attempting to control the other furnaces are inexperienced in metallurgical problems. The note is an interesting contribution, and we hope the authors will complete it by others giving the result of their further experience.

POWER STATION FUEL CONSUMPTIONS.

Statistics of the performances of British electric power stations for the year ending March 31 last have just been published by the Electricity Commission. The corresponding figures for the year ending March 31, 1922, were not published until last March, so that the present returns have taken some six months less in preparation than the previous set. This saving in time is gratifying and shows that power station authorities are more fully appreciating the value of the Commissioners' work and are sending in returns more promptly. One of the most interesting points brought out by the new figures is an increase in total output of 854 million units during the period under review as compared with the previous twelve months, the total output being 5,456,020,960 units. The increase shown is 17·5 per cent., which is a striking figure for a year marked by such trade depression and shows that electricity is continuing to take the place of other power and lighting agencies. The fuel consumption figures are the most interesting features of the publication. The average coal consumption per unit generated for the whole country was 2·78 lb. This compares with a figure of 3·11 lb. for last year and marks a satisfactory movement in the right direction. The result of this improvement is that the additional output of 17·5 per cent. has been attained with an increase in fuel consumption of only 3 per cent. As in the previous returns, the figures for the best station in each group have been quoted, but in the present instance with the addition of the name of the best stations, so that it will be possible for an engineer in comparing his results with the best obtained to know definitely the type of station he is comparing his own performance with. The groups refer to the size of stations, having nothing to do with geographical distribution, and it is very greatly to the credit of the engineers of the North-East Coast that one of their stations stands at the head of each of the first three groups. Group A, which covers stations of over 200 million units output, is headed by Carville B, with a fuel consumption of 1·74 lb. Group B, which represents stations between 100 million and 200 million units output, is headed by Dunston, with a figure of 1·91, and Group C containing stations between 50 and 100 million units output by North Tees, with a figure of 1·73. This figure of 1·73 is the best returned, but Carville B, with a percentage of 17·8, shows a slightly better thermal efficiency than North Tees, the figure of which is 17·15. Among the best stations in the other groups there are five municipal stations of which the more important are those at Sheffield, Rotherham and Hackney. The two smaller stations are those at Finchley and Horsham, both of these latter being composite stations using coal and oil. It is interesting to note that Group A, which covers stations generating over 200 million units, contains three stations against two in the previous year's returns. One of these stations is situated in the London area, and it is not altogether satisfactory to see that it has a coal consumption of 2·31 lb. The return covers 532 stations in all, as compared with 536 in the previous issue. The return may be obtained from H.M. Stationery Office or through any bookseller at 1*s.* 6*d.* net.

"HUTTE DES INGENIEURS TASCHENBUCH": ERRATUM.—On page 172 of our issue of August 10, we noticed the publication of the second volume of the 24th edition of the *Hutte des Ingenieurs Taschenbuch*. We regret that we erroneously ascribed the publication to Messrs. Wilhelm Engelmann und Sohn, of Berlin. The publishers of this old-established pocket book are, of course, Messrs. Wilhelm Ernst und Sohn, of Berlin, to whom we extend our apology.

THE "VICKCEN" CENTRIFUGAL OIL SEPARATOR.

THE provision of some means of purifying lubricating oil, to eliminate water, dirt, carbon and other deleterious substances, is essential in the prevention of waste. Without that facility the oil would be kept in use for a longer period than is advisable with a consequent loss in efficiency and the possibility, if the action is continued, of injury to the plant. It is quite unnecessary to dwell on the subject of the effects caused by the matter accumulated by lubricating oil, or of those contained or acquired by accident in fuel oil for engines, or again of the evil effects resulting from the presence of water or sludge in the insulating oils used with transformers or switch gear. The effects are known and their significance appreciated. What is not always recognised is that the process of removal of the impurities need not be one taking a long time for its achievement. Simple filtration and sedimentation processes are very slow and in some cases, for instance at sea, the successful use of settling tanks is almost impossible. Centrifugal separation has many advantages for this service whether it is used as a continuous process or at periods when the oil has reached a state which warrants it being drawn off for treatment.

The production of centrifugal separators has been for a long time in the hands of American and Continental organisations. A machine has been put on the market recently, however, which is entirely the product of British labour. This machine, the "Vickcen" separator, is being manufactured by Messrs. British Separators, Limited, of 161, Queen's-road, Peckham, London, S.E. It is illustrated on page 302 by vertical and horizontal sections in Figs. 1 and 2, while the construction of the bowl, which is the essential part of the machine, is shown in Fig. 4. The general appearance of a complete plant with a self-contained electric drive is given in Fig. 3.

The bowl forms an outer casing of sturdy construction within which there is a long-necked conical casting which has a series of circular holes drilled through it near its bottom edge. On four keys on that casting, one wider than the other three to make incorrect assembly impossible, a number of cones made of thin sheet metal are mounted. These cones are held apart from each other by narrow spacing pieces, which are welded to their upper surfaces. There are two sets of holes in the cones, the first being near the bottom edge, while the other is grouped around the opening which surrounds the spindle. When all the thin metal cones are in place a thicker cast one is mounted above them. The bowl is closed by a cover provided with rubber packing to prevent leakage and firmly held in position by a screwed ring. A similar construction is used to hold a ring-shaped discharge disc on its top. The opening in this is suited to the requirements of the fluid dealt with and different sizes are used for the various substances handled.

The fluid, which is to be separated into its lighter and heavier components and freed from solid matter, is passed down the centre tube from the container above where there is a gauze strainer for the elimination of coarse impurities. When the machine is running the liquid enters the bowl and passes under the base cone and through the small holes in it. As it passes on through the holes in the thin cones the heavier material is thrown out into the bowl, where the heavier solids remain, but the heavier fluid is sent up through the channels between the top cast cone and the cover, and carries with it the lighter solids. After passing through the ring plate it discharges into the bottom trap, from which it is taken away by the spout. While that operation is in progress, the lighter component of the fluid rises within the spaces between the cones and passes through the upper holes to the top, and is conducted within the top cast cone and up the cylindrical neck to the second trap. A third trap is provided above the others in case there is any congestion caused by dirt, in which case the fluid would not pass through the bowl but would overflow at the inlet, and the escape of any fluid from this top trap would give effective indication of the stoppage.

A gun-metal ring put on the bowl, after heating and expanding, serves for braking purposes. The brake which operates on this consists of a spring-held plunger with a Ferodo cap on its end. A hand lever outside the casting is provided to put the brake into and out of operation. Oil from the lubricator at the side of the machine, is conducted to the bearing below the bowl. The bushes for this are made in three parts and held against the spindle by six small helical springs. From here the oil falls to the next bearing and eventually passes into the well as make-up. The spindle sits on the top of, and derives its motion from, a worm shaft which receives its drive from a worm wheel. This drive is housed within the base of the machine, which is provided with an inspection door. When the plant is running, the oil from the well is thrown up and some of it is caught by the small trough at the side and con-

ducted to the bearings of the wheel. An overflow pipe carries away dirty oil from the bottom of the well and the same level is thus maintained. The bottom bearing is of the double roller type and takes any thrust due to the drive.

The separator operates successfully no matter what may be the changes in the proportions of the two constituents. If after a time, only the heavier liquid were passed in as the feed there would be practically no displacement of the lighter liquid already in the bowl. Should the material which is treated contain only small quantities of solid matter and very little of the heavier liquid, the machine may be used as a super-clarifier. For this purpose the long top cone plate is replaced by a shorter one and a discharge disc with a smaller hole inserted. In this case the whole of the solid matter and the heavier liquid would be thrown into the sediment space of the bowl and remain there until removed. There are, of course, many other applications for these machines in industrial work besides that of oil purification to which we have referred because of its interest to engineers.

The machines are supplied complete with an electric motor for driving purposes or with the requisite fast and loose pulley and striker gear for belt drive. A complete unit with motor drive is shown in Fig. 3. The motor is erected on a movable bracket with a heavy nut and screw between it and the main body of the machine, for use in tightening the belt. Within the outer pulley there is another one keyed to the shaft. These are connected by means of two small castings with Ferodo facings which are brought into the full operating position by centrifugal force. By this means the starting torque of the motor is kept down, and the machine is gradually accelerated without special starters or belt slipping devices. The arrangement in use on the belt-driven machine is shown on the drawing, Fig. 2. The belt striker gear, which can be set in any position, has as its base a nut which is moved laterally by turning its screw by hand. A ratchet and pawl are provided in this model as a precaution to prevent the rotation of the bowl in the wrong direction. At the end of the shaft remote from the pulley there is a small fitment for use in testing the speed of running.

The machine is supplied in many sizes ranging from a capacity of 10 gallons per hour to one of 600 gallons per hour. The power required to drive the largest set is less than 2 h.p., while the smallest unit only needs about ¼ h.p. All the parts are standardised and made to limit gauges to ensure that they are interchangeable, and replacements can be obtained immediately the necessity for them arises.

Cape Town Water Works.—H.M. Trade Commissioner at Cape Town has forwarded to the Department of Overseas Trade an extract from the minutes of the proceedings of the Corporation of the City of Cape Town in which it is recorded that the Waterworks Committee have recommended the adoption of a scheme for the extension of the water supply at an estimated cost of 1,090,000*l.* The extract referred to and press cuttings can be seen by British firms at the Department of Overseas Trade, Room 50.

The Power Factor and Slip of an Induction Generator: Erratum.—Our attention has been drawn to the fact that in this article an error has crept in in the third column, page 282, *ante*, where

$$\frac{W_o}{W_r} \times \frac{n_s}{n_r} = \frac{1}{S+1}$$

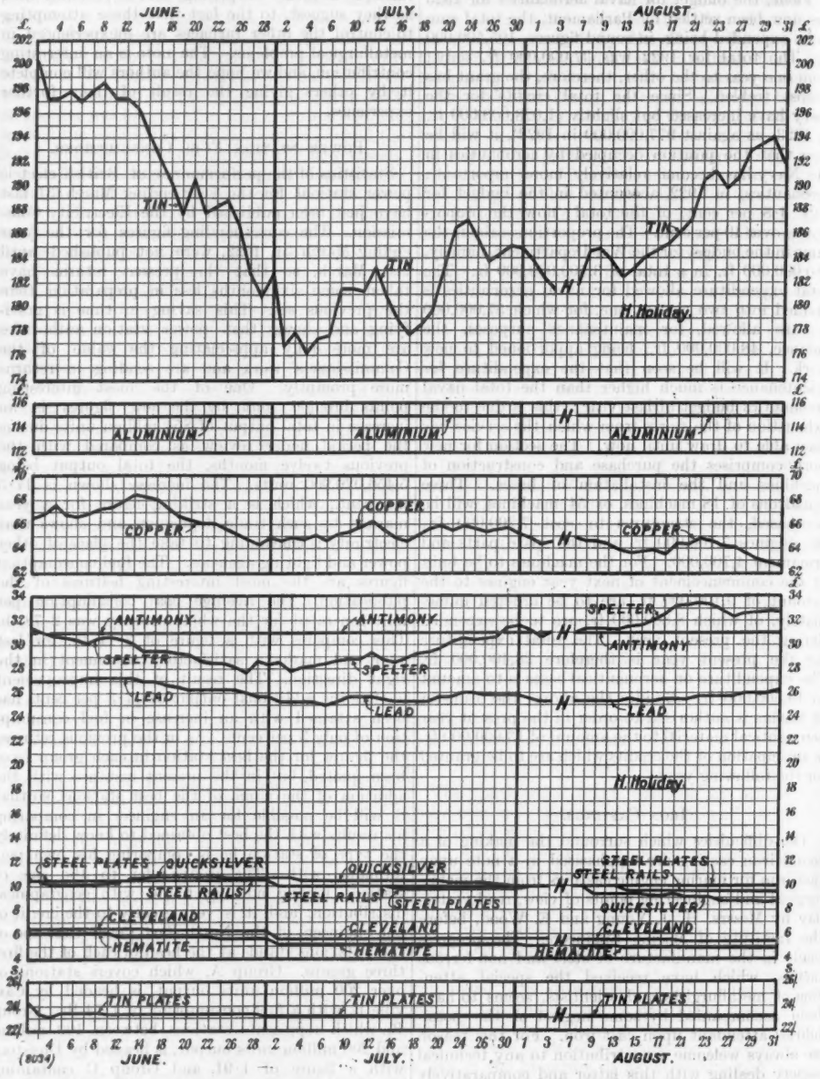
should read

$$\frac{W_o}{W_r} = \frac{n_s}{n_r} = \frac{1}{S+1}$$

Contracts.—The contract for the electrification of the Campos do Jordao Railway, Brazil, has been awarded to the English Electric Company, Limited, by the Government of Sao Paulo. This contract covers the electrification of an existing metre-gauge railway, and includes the supply and erection of about 30 miles of overhead catenary construction on the 1,500 volt direct-current system and some 15 miles of 30,000 volt, 3-phase transmission line. It also includes the building and equipment of a sub-station as well as motor coaches for passenger and freight service. The 30,000 volt, 3-phase, 50-cycle supply current will be transformed down to 2,000 volts at the sub-station where a 500 kw. synchronous motor generator set will convert into direct current at 1,500 volts. The passenger coaches are to seat 40 passengers and the freight coaches, which are of the covered type, are to carry 10 tons. The electrical equipment of each type of motor coach will comprise four direct-current self-ventilated traction motors, each wound for 750 volts. The motors are connected two in series and the two pairs operated in series parallel. The electrification of this line is of particular interest, owing to the fact that one-third of the total route length is level, the remainder being over gradients of which the most severe is 10½ per cent., there being some eight miles of track on which the gradients vary from 6 per cent. to 10½ per cent. In view of this the motor coaches are to be equipped with four different braking systems, these being hand, air, rheostatic and electro-magnetic track brakes, of which the last named is intended for use in emergencies only.

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN PRICES OF METALS

(Specially Compiled from Official Reports of London Metal Markets.)



Note.—In the diagrams the figures plotted for tin and copper are the official closing cash quotations of the London Metal Exchange for fine "foreign" and "standard" metal respectively. The prices shown for lead are for English metal, whilst those for spelter are for American metal. Middlesbrough prices are plotted for steel plates and rails, and also for hematite and Cleveland pig-iron. The prices given, in the case of steel plates are for ship, bridge and tank qualities, and those for steel rails are for heavy sections. The pig-iron prices are for East Coast hematite and Cleveland iron, both of No. 1 quality and for home consumption. The price of tin-plates is per box of I.C. cokes f.o.b. at Welsh ports, but in all other cases the prices are per ton. Each vertical line in the diagram represents a market-day, and the horizontal lines represent 1*l.* each, except in the case of the diagram relating to tin-plates, where they represent 1*s.* each.

Peninsular and Oriental Liner Mongolia; Addendum.—With reference to the article describing this vessel which appeared on page 231 of August 24 Messrs. Clarke, Chapman and Co., Limited, of Gateshead-on-Tyne, inform us that they supplied the whole of the steam winches, auxiliary feed pumps, ballast pumps, sanitary pump, bilge pump, oil-fuel transfer pumps, fire and bilge pumps and the electrically-driven emergency bilge pump for the ship, in addition to the windlass which we mentioned as being of their manufacture.

Danish Shipbuilding and the Ruhr Occupation.—Several Danish industries are handicapped at present owing to the difficulty of obtaining delivery of German materials as a result of the occupation of the Ruhr. This applies more especially to the shipbuilding industry, and Burmeister and Wain, for instance, have not been able to commence the building of a war vessel which ought to have been taken in hand some time ago. The materials in question were ordered from the Ruhr district before the occupation, but they were not rolled before that event.

University of Bristol.—We have received the calendar for the sixty-eighth session, 1923–1924, of the Faculty of Engineering, University of Bristol, provided and maintained in the Merchant Venturers' Technical College. The courses of study in the college cover a very large number of engineering, commercial technical and trade subjects; there are also very complete evening classes and a very interesting list of popular lectures. The facilities provided by the establishment for education and training constitute a real boon for the inhabitants of West of England.

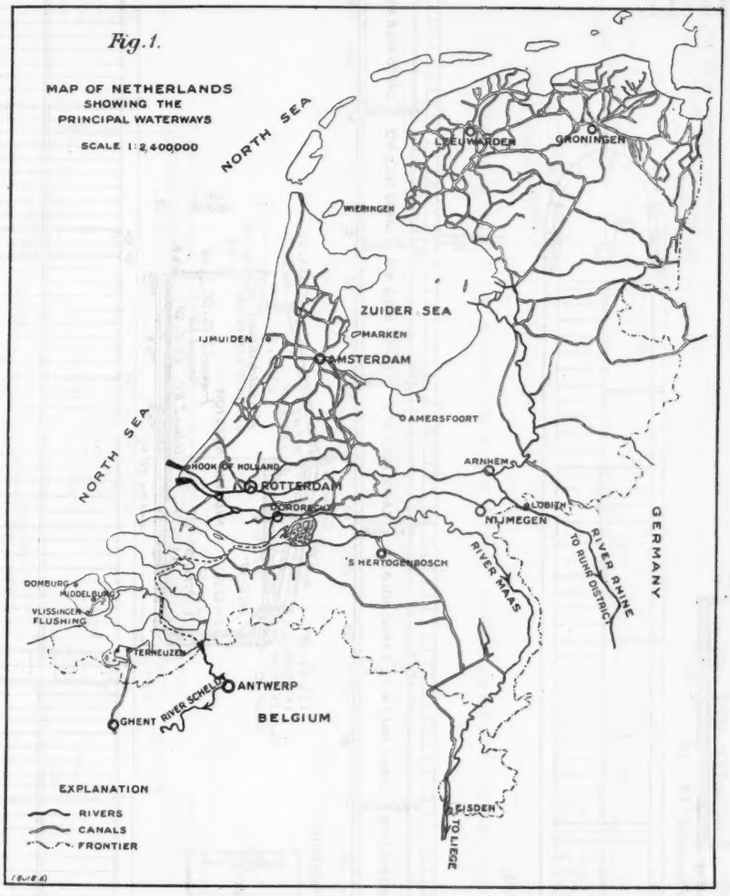
The Institution of Aeronautical Engineers.—The Minutes of the Proceedings of this Institution, which have just been issued, contain a reprint of a paper on Obtaining Experimental Data without a Wind Channel, by Major O. T. Gnosspelius which was referred to on page 777 of our 114th volume, a report of a discussion on the Itford trials of gliders, a paper on Wind Tunnel Work at the N.P.L. by Mr. W. L. Cowley, and a report of the proceedings at the 5th annual meeting, held on March 9 last, when a Presidential Address and Lecture on Aerial Photography was delivered by Lieut.-Colonel J. T. C. Moore-Brabazon, M.C., M.P. Copies of the proceedings can be obtained from the Secretary of the Institution, 60, Chancery-lane, W.C.2, price 1*s.* 6*d.* net, and the four previous issues of the proceedings are also obtainable at the same price.

DUTCH RIVER LIGHTERS.*

By MR. A. M. SCHIPPERS, Eng., Member.

HOLLAND is a small country and a considerable part of it consists of water. As the map (Fig. 1) shows, the West and North coasts are bounded by the North Sea, and it also possesses an inland sea, the Zuidersee, containing the well-known islands of Marken and Wieringen. The most important river, the Rhine, rises in Switzerland and enters Holland via Germany near Lobith, and it flows through the rivers Waal, Lek, Hollandsch Diep, Merwede, Oude and Nieuwe Maas to the North Sea. These rivers are the principal lines of communication from Rotterdam and Amsterdam to the well-known Ruhr district. The Maas is a river coming from France via Belgium near Visé into Holland, and for the greater part of its upper reaches is not navigable owing to lack of water, but the Dutch Government is now engaged in greatly improving this river. The Scheldt also flows through Holland to the North Sea, and makes Antwerp a seaport. Further, a large number of small rivers flow across Holland, but not content with all this water they have in addition made a great number of canals for the drainage of the low-lying fields and for shipping—

Fig. 1.



big ones for the shipping only. To the latter category belongs the North Sea Canal, which connects Amsterdam with the North Sea near Ymuiden, so that all but the biggest steamships can approach that port; the Merwede Canal that connects Amsterdam with the River Rhine; the Canal of Terneuzen to Ghent in Belgium and the Zuid Bevelandsche Kanaal, which connects Antwerp via the Scheldt and different Dutch rivers with the Rhine. Also the important water connection between Antwerp and Liège runs via this Zuid Beveland Canal and some Dutch rivers and other Dutch canals.

It is not surprising, therefore, that the transport of goods in Holland and in Switzerland, Germany, France and Belgium mainly takes place by water, and that an enormous number of river and canal boats are owned in these countries, the great part of which are built in Holland. These inland vessels comprise sailing ships, steamships, motor boats, lighters and tugs, and their deadweight capacity varies from 10 to 3,500 tons (of 1,000 kg.). It would carry the author too far to give details of all these kinds of ships, so that he restricts himself chiefly to the big river lighters.

Principal dimensions and deadweight capacity.—These are laid down in an official Government certificate called the "Tonnage Certificate." The length given in this document is not the length between perpendiculars but the length *over all*. The reason for this is that for passing the locks the length over all is of special importance. For the same reason the official tonnage certificate does not state the breadth *moulded* but the *extreme* breadth. Neither the moulded depth nor the depth of holds is mentioned, but the *light* and *loaded draughts* are not only written down in the certificate but also cut on the ship's hull on both sides in three places along the side of the ship. A Government surveyor fixes for every river boat, according to Moorson's system, the deadweight capacity—not only the maximum deadweight, but also the deadweight at every tenth of a metre immersion. In this way he makes a complete deadweight scale, which is shown in the certificate in question. The maximum deadweight capacity is that calculated with a freeboard = zero, and in practice all the river lighters are used with no freeboard at all. The hatchway coamings and the shear give the ship her reserve buoyancy.

This system of measurement of the river boats is exactly the same in Germany, Belgium and France, and the Government tonnage certificates are reciprocally recognised. This system with a deadweight scale on the tonnage certificate is very simple and practicable, because it enables one to control immediately the deadweight of a complete as well as of a partly loaded ship. Even to control the weight of the discharged cargo of a sea-going ship there is used the officially measured river lighters. The gross and net registered tonnage, which has already given so much trouble in the sea-going ships, is fortunately unknown in our river shipping trade. All the harbour, lock and quay charges are paid for on a basis of the maximum deadweight. Besides the above-mentioned sizes the height of the empty ship above the light load water-line is still very important, with a view of passing under the bridges.

Type of river lighters according to their dimensions.—The depths of the rivers, the sizes of the canals, locks and bridges fix the maximum principal dimensions of the river boats. This is the reason why we have river boats from 10 up to 3,500 tons deadweight. The very small lock near Wijk bij Duurstede reduces the maximum dimensions of the ships to 17 × 3·70 × 0·85 m. (draught). The larger river lighters may be classified in standard types.

No. 1. The Sambre Ship.—This type of vessel has the following dimensions:—Length (over all) = 46·95 m.; breadth (extreme) = 5·03 m.; depth (moulded) = 2·35 m.; deadweight on 2·35 m. draught = 410 tons of 1,000 kg.; deadweight on 2·10 m. draught = 380 tons of 1,000 kg.

An arrangement plan and midship section of a Sambre ship is given in Fig. 2, page 312. This type of ship is specially used in the southern Dutch canals and in the Belgian and French small canal trade. The midship section shows that the midship section coefficient = 1, and how very light the plates and angles are. Thus the shell plating = 6 mm. and one strake is only 5 mm. The frames, 65 × 50 × 6 mm., are bent in the bilge, but the bilge and bottom plates are connected by an outside angle-iron of 70 × 70 × 7 mm. The three cargo holds have an enormous cubic capacity. The crew consists of one man, who lives in the forepeak, and the captain with his family have their accommodation aft. The maximum height of the empty ship above the light water-line is 3·35 m. aft and forward, in which case anchor davit, mast, deck cabin and rudder are lowered.

No. 2. The Spits Ship.—This type is similar to the Sambre ship, but with a length (over all) of 45·90 m., a breadth (extreme) of 5·59 m., and a depth (moulded) of 2·17 m. maximum deadweight on 2·17 m. draught = 420 tons of 1,000 kg.

This type of ship is specially used on the Belgian and French canals.

No. 3. The Kempenaar Ship.—The dimensions of this type are as follows:—Length (over all) = 50 m.; breadth (extreme) = 6·60 m.; depth (moulded) = 2·15 to 2·25 m.; deadweight on 2·20 m. draught = 520 tons of 1,000 kg. This type of ship is most used in the trade from Liège to Antwerp, and in construction she is rather like the Sambre ship but with curved bilge plates and is more heavily built. The minimum thickness of the shell plates is 6 mm., bilge and sheer-strake plates are 7 or 8 mm.

No. 4. The Brusselaar Ship.—This type has the following dimensions:—Length (over all) = 59·60 m.; breadth (extreme) = 7·81 m.; depth (moulded) = 2·06 m.; deadweight on 2·40 m. draught = 700 tons of 1,000 kg.

This type of ship is specially built for the Brussels canal trade, but is too broad for the Liège trade. She is otherwise constructed like the *Kempenaar* type.

No. 5. The Dortmund-Ems Canal Ship.—This type of vessel has a length (over all) of 66·70 m.; breadth (extreme) = 8·20 m.; breadth (moulded) = 8·14 m.; depth (moulded) = 2·40 m.; deadweight on 2·40 m. draught = 925 tons of 1,000 kg.; deadweight on 2 m. draught = 730 tons of 1,000 kg.

A general arrangement plan and midship section, &c., of this type of ship are given in Fig. 3, page 312.

The ship has nine cargo holds, five steel bulkheads, six wooden temporary bulkheads, crew accommodation in the forepeak and accommodation for the captain and family aft. The author draws attention to the fact that the ship has no bottom keelsons nor hold stringers. The longitudinal strength has been brought into the hatch coaming plates (with an extra strip), the extra sheer plate and the bilge plates.

No. 6. The Rhine-Herne Canal Ship.—The dimensions of this type are: Length (over all) = 79·95 m.; length (between perpendiculars) = 78 m.; breadth (extreme) = 9·43 m.; depth (moulded) = 2·50 m.; height of the empty ship above the light water-line = 4·20 m.; deadweight on 2·50 m. draught = 1,350 tons of 1,000 kg.; displacement on 2·50 m. draught = 1,665 tons of 1,000 kg.

This ship has 10 cargo holds and is otherwise constructed like type No. 5.

Besides these six standard types we find a great number of vessels, generally called "Rhine ships," of larger dimensions than those hitherto mentioned. These ships are specially in the trade of Rotterdam, Antwerp and Amsterdam to the Ruhr district and the German portion of the Rhine. The principal (extreme) dimensions and maximum deadweight capacity of these ships are as follows:—

—	Length (over all).	Breadth (extreme).	Depth (moulded).	Draught.	Maximum deadweight.
	Metres.	Metres.	Metres.	Metres.	Tons.
No. 1	78·20	9·43	2·55	2·50	1,380
No. 2	82	10	2·70	2·70	1,500
No. 3	85	11	2·60	2·60	1,700
No. 4	85	11	2·65	2·65	1,800
No. 5	85·50	11·15	2·58	2·58	2,000
No. 6	92·30	11·59	2·70	2·70	2,170
No. 7	93	11·59	2·80	2·80	2,225
No. 8	95	11·59	2·82	2·82	2,300
No. 9	120	14	2·80	2·80	3,583

Ship No. 9, of 3,583 tons deadweight, is the *Karl Schreurs* 3A, built in 1909 by the N.V. Werf De Noord at Alblasserdam, and is the largest river lighter in the world. She has 17 cargo holds and the general arrangement is shown in the National Technical Shipping and Shipbuilding Institute and Museum at Rotterdam.

Proportions and coefficients.—The proportions of length to depth are the most remarkable in this type of ship.

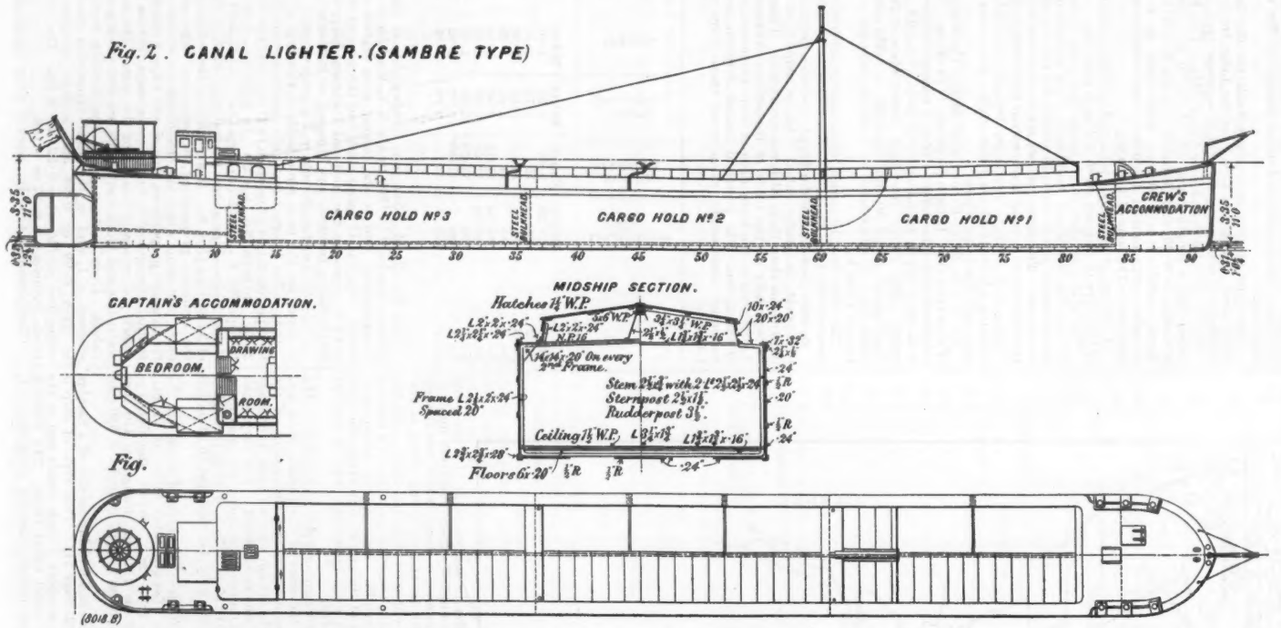
In type No. 1, length (over all) : depth (moulded) = 20. In type No. 2 this proportion is 21·1. In type No. 3 = 22·7. In type No. 4 = 29. In type No. 5 = 28·52. In type No. 6 = 34·2. In type No. 7 = 32, and in the bigger Rhine ships about 32, and even 42·8 in the ship of 3,583 tons (No. 9). If we compare these figures with the ordinary proportions in seagoing ships and the extra provisions which the classification societies require for extreme proportions, one should expect extra longitudinal strengthening in the river ships, but as will be shown you presently this is not the case. The midship, water-line and block coefficients are also of very unusual values. Even in type No. 1 the midship section coefficient = 1, and in the other types this coefficient is often 0·99 or 0·98 and seldom smaller. The water-line coefficient = 0·92 to 0·94. The ordinary block coefficient = 0·87 or 0·88.

Classification, &c.—In general river ships are not

*[A Paper read at the Summer Meeting of the Institution of Naval Architects, held in Holland, September 3, 1923.]

DUTCH RIVER LIGHTERS.

Fig. 2. CANAL LIGHTER. (SAMBRE TYPE)



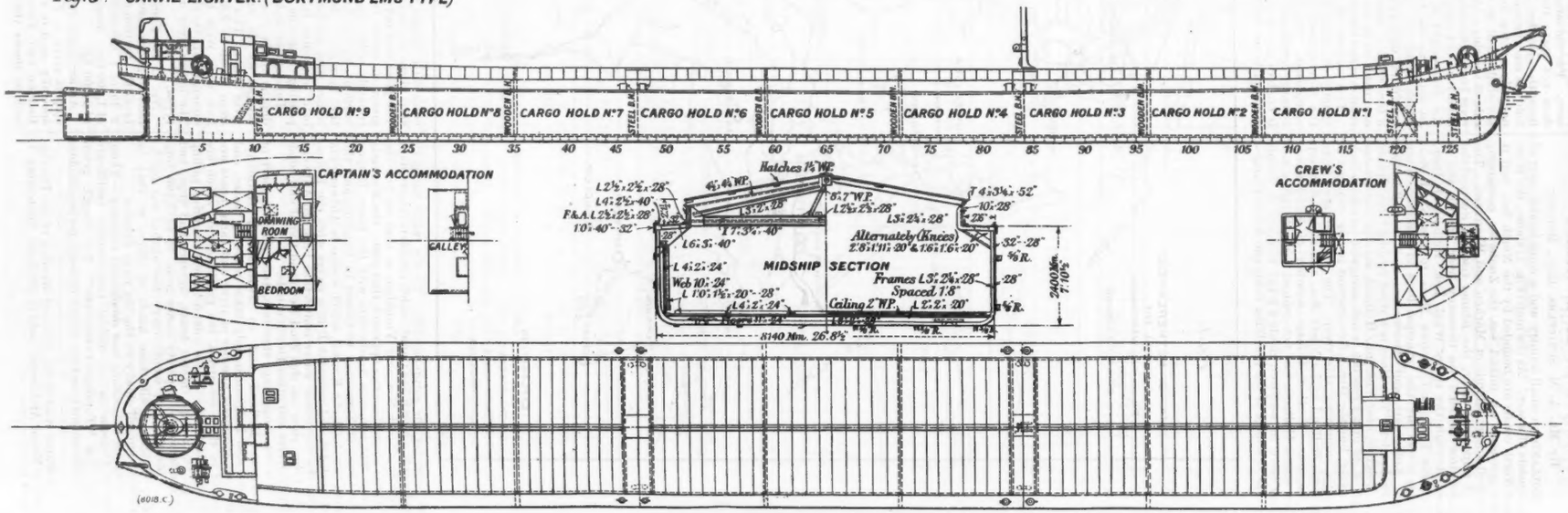
CANAL LIGHTER (SAMBRE TYPE).
BUILT BY MESSRS. DE HAAN AND OERLEMANS, HEUSDEN.
Principal Dimensions.

Length (over all)	=	46·95 metre 154 ft. 0½ in.
Length (between perp.)	=	46·03 metre 151 ft. 0½ in.
Breadth (extreme)	=	5·03 metre 16 ft. 6 in.
Breadth (moulded)	=	5·00 metre 16 ft. 4½ in.
Depth (moulded)	=	2·35 metre 7 ft. 8½ in.
Deadweight on 2·35 m. draft	=	410 tons of 1,000 kg.
Deadweight on 2·10 m. draft	=	380 tons of 1,000 kg.

CANAL LIGHTER (DORTMUND EMS TYPE).
BUILT BY LOBITSCHE SHIPBUILDING COMPANY, LOBITH.
Principal Dimensions.

Length (over all)	=	66·70 metre 218 ft. 10 in.
Length (between perp.)	=	65·00 metre 213 ft. 3 in.
Breadth (extreme)	=	8·20 metre 26 ft. 11 in.
Breadth (moulded)	=	8·14 metre 26 ft. 8½ in.
Depth (moulded)	=	2·40 metre 7 ft. 10½ in.
Deadweight on 2·40 m. draft	=	925 tons of 1,000 kg.
Deadweight on 2·00 m. draft	=	730 tons of 1,000 kg.

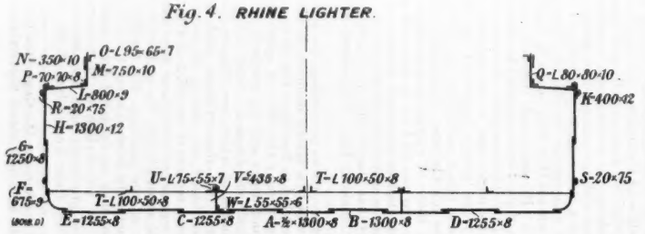
Fig. 3. CANAL LIGHTER. (DORTMUND EMS TYPE)



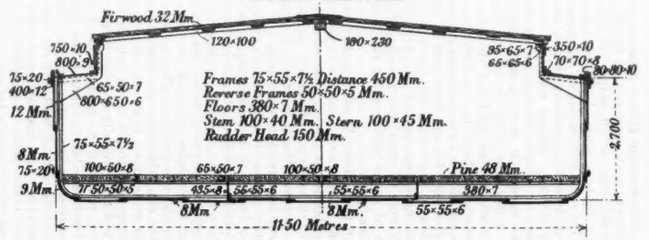
DUTCH RIVER LIGHTERS.

DUTCH RIVER LIGHTERS.

Fig. 4. RHINE LIGHTER.



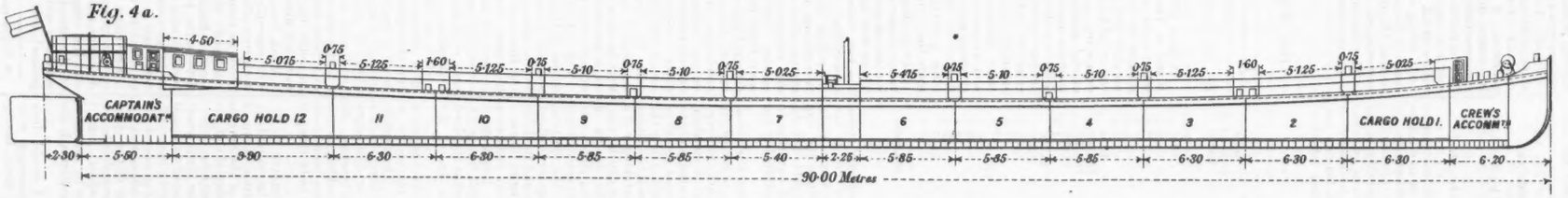
MIDSHIP SECTION.



RHINE LIGHTER.

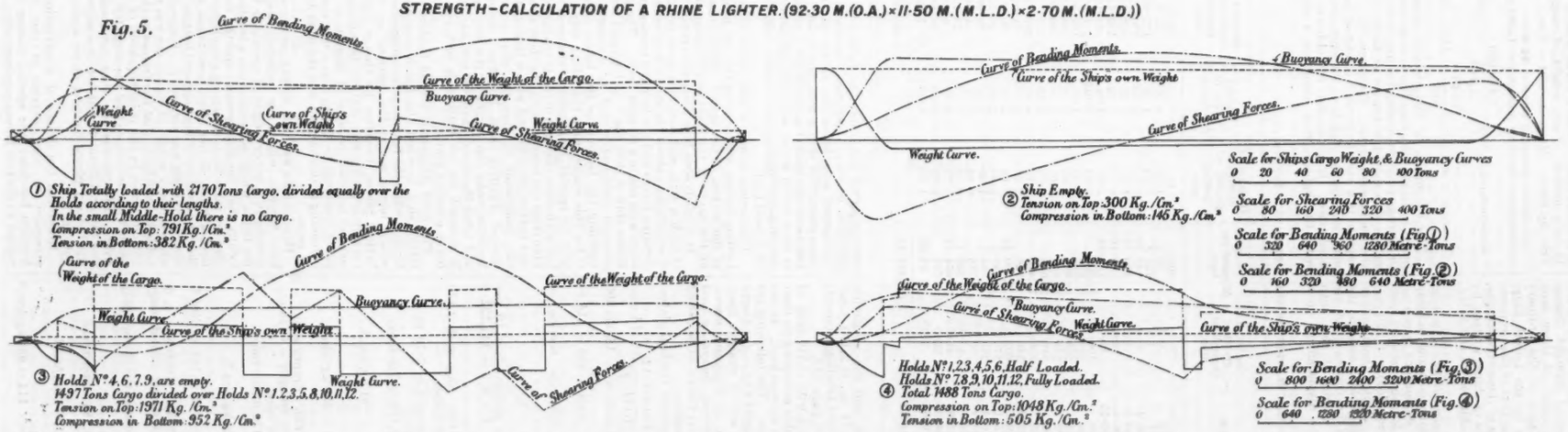
Length (over all)	= 92·30 metre
Length (between perp.)	= 90·00 metre
Breadth (extreme)	= 11·59 metre
Breadth (moulded)	= 11·50 metre
Depth (moulded)	= 2·70 metre
Displacement (on 2·70 m. draft)	= 2,570 tons of 1,000 kg.
Deadweight (on 2·70 m. draft) ..	= 2,170 tons of 1,000 kg.

Fig. 4a.



STRENGTH-CALCULATION OF A RHINE LIGHTER. (92·30 M. (O.A.) × 11·50 M. (M.L.D.) × 2·70 M. (M.L.D.))

Fig. 5.


Curve of Bending Moments.
Curve of the Weight of the Cargo.
Buoyancy Curve.
Weight Curve
Curve of Shearing Forces.
Curve of Ship's own Weight
Weight Curve.
Curve of Shearing Forces.
① Ship Totally loaded with 2170 Tons Cargo, divided equally over the Holds according to their lengths. In the small Middle-Hold there is no Cargo.
Compression on Top: 791 Kg./Cm.²
Tension in Bottom: 382 Kg./Cm.²
Curve of Bending Moments
Curve of the Weight of the Cargo.
Curve of the Weight of the Cargo.
Buoyancy Curve.
Weight Curve
Curve of the Ship's own Weight
Weight Curve.
Curve of Shearing Forces.
③ Holds N°4, 6, 7, 9, are empty. 1497 Tons Cargo divided over Holds N° 1, 2, 3, 5, 8, 10, 11, 12.
Tension on Top: 1971 Kg./Cm.²
Compression in Bottom: 952 Kg./Cm.²
Curve of Bending Moments.
Curve of the Ship's own Weight
Buoyancy Curve.
Weight Curve.
Curve of Shearing Forces.
② Ship Empty.
Tension on Top: 300 Kg./Cm.²
Compression in Bottom: 145 Kg./Cm.²
Scale for Ships Cargo Weight, & Buoyancy Curves
0 20 40 60 80 100 Tons
Scale for Shearing Forces
0 80 160 240 320 400 Tons
Scale for Bending Moments (Fig ①)
0 320 640 960 1280 Metre-Tons
Scale for Bending Moments (Fig ②)
0 160 320 480 640 Metre-Tons
Curve of Bending Moments
Curve of the Weight of the Cargo.
Buoyancy Curve.
Curve of Shearing Forces.
Weight Curve.
Curve of the Ship's own Weight
Holds N° 1, 2, 3, 4, 5, 6, Half Loaded.
Holds N° 7, 8, 9, 10, 11, 12, Fully Loaded.
④ Total 1488 Tons Cargo.
Compression on Top: 1048 Kg./Cm.²
Tension in Bottom: 505 Kg./Cm.²
Scale for Bending Moments (Fig ③)
0 800 1600 2400 3200 Metre-Tons
Scale for Bending Moments (Fig. ④)
0 640 1280 1920 Metre-Tons

classified by any of the existing societies. The Bureau Veritas and the German Lloyd have made special rules for river ships, but these rules are practically of no value, because they are not according to practice; they are too theoretical and not sufficiently independent of the rules laid down for seagoing ships. As will be explained presently long river ships cannot be considered as merely a stiff beam, as we used to do with seagoing ships. As far as the author knows Lloyd's Register Society has never interested itself in this special subject, and special rules for river ships based on the experiences in Holland would have a good chance of success in future, and also for use in the United Kingdom.

The difference between the Rhine ships as really built and those designed according to Bureau Veritas and the Germanischer Lloyd rules is very clearly shown in the paper, "Deutscher Fluszschiffbau unter Berücksichtigung heutiger Wirtschaftlichkeitsfragen," read by Dr. Ing. Gustav Wrobbel before the Society of German Shipbuilders. Dr. Wrobbel, who is the chief naval architect of the Lobith Shipbuilding Company at Lobith, gives in his paper very interesting data about Rhine-Herne canal ships.

In Germany there exists a *Rheinschifferegister Verband*, a society controlled by some German insurance companies which control in their own way the Rhine ships and publish a register book. This register book has some value, but the control of the ships themselves is not very important. But a contract between Holland and Germany, signed in 1868, and known under the name of *Rijnvaart Akte*, contains provisions for the Rhine ships themselves, their outfit, their crew, &c.

In spite of the fact that the river ships are built unclassified and not under control of a large staff of Government surveyors, the life of such ships is very long (30 to 40 years); the cost of repairs very small, and the risk of loss of human lives by reason of unseaworthiness practically nil. That the general risk for accidents is a small one can best be proved by the small insurance premium of about 2 per cent. per annum. Only about once in two years the owners have their ships placed on a slipway and a coat of common cheap coal tar gives protection for the steel bottom. Composition paints are never applied. The slipways for repairing this kind of ship are all built for sideways docking and most are electrically driven. On the other hand, building slips are nearly always laid for end launching because otherwise these long ships require such a great length on the riverside. The inclination for launching is about 1 in 18 or 1 in 20.

Resistance in towing.—Only the small river ships of 40 to 200 tons are self-propelled, and most of them are fitted with crude oil motors. The lighters are all towed by tugs, the power of which varies from 120 to 1,300 i.h.p. According to the power of the tug and the force of the stream two or four lighters are towed together. As can be readily understood it makes a big difference whether the towing takes place in summer or in winter and up or down stream. As far as I know not many figures about the theoretical resistance of river ships have been published, but in 1922 the Lobith Shipbuild ng Company at Lobith took the trouble to make very important trials in the experimental tank at Hamburg. Two different models of Rhine-Herne canal ships (78 × 9·43 × 2·50 m.)

were tested in the tank, one being of the ordinary type with round bows, frames and water-lines and the other a model with specially constructed straight frames only curved at the bilges. The result of these tank experiments was that the resistance of the ordinary form as built during many years by the Lobith Shipbuilding Company was far less than that of the proposed new form. A complete description of these experiments, giving the lines of these two types of ships, written by Dr. Ing. G. Wrobbel, has been published in *Het Schip*, 1923, page 105.

Construction and statical strength calculations.—Fig. 4, on page 313, shows the general arrangement and midship section of a Rhine ship of the dimensions given:—Length (over all) = 92·30 m.; length (between perpendiculars) = 90 m.; breadth (moulded) = 11·50 m.; breadth (extreme) = 11·59 m.; depth (moulded) = 2·70 m. This ship has 12 cargo holds, and in the middle of her length a small hold of five frames which are not used for cargo. The light weight of this ship completely fitted = 400 tons. The displacement on a draught of 2·70 m. is 2,570 tons, and the maximum deadweight on a draught of 2·70 m. is 2,170 tons. Calculations of the shearing forces and bending moments for four cases are shown in Fig. 5 on page 313.

CALCULATION OF THE MOMENT OF INERTIA.

	Scantlings.	Area.	Centre of gravity above base line.	Moment on base.	Distance of centre of gravity to neutral axis.	Second power of this distance.	Moment of inertia on neutral axis.	Ship's moment of inertia.
	cm.	sq. cm.	cm.	cm.³	m.	m.²	cm.²m.²	cm.⁴
A	65 × 0·8	52	0·4	20·8	1·14	1·30	67·6	2·7
B	130 × 0·8	104	1·2	124·8	1·13	1·27	132·08	5·5
C	125·5 × 0·8	100·4	0·4	40·16	1·14	1·30	130·52	5·3
D	125·5 × 0·8	100·4	1·2	120·78	1·13	1·27	127·51	5·3
E	125·5 × 0·8	100·4	0·4	40·16	1·14	1·30	130·52	5·3
F	67·5 × 0·9	60·75	12·5	759·94	1·02	1·04	63·18	6,834
G	125 × 0·8	100	100	10,000	0·14	0·0196	1·96	130,208
H	130 × 1·2	156	217	33,852	1·03	1·06	165·36	219,700
K	40 × 1·2	48	263	12,624	1·49	2·22	106·57	64,000
L	80 × 0·9	72	275	19,800	1·61	2·59	186·48	4·8
M	75 × 1	75	318	23,050	2·04	4·16	312	35,156
N	35 × 1	35	326	11,410	2·12	4·49	157·15	3,573
O	L 95 × 65 × 7 ..	13·9	340	4,726	2·26	5·11	71·03	80·8
P	L 70 × 70 × 8 ..	10·64	202	3,000·48	1·68	2·82	30·00	47·5
Q	L 80 × 80 × 10 ..	15·1	278	4,197·8	1·64	2·69	40·62	87·5
R	2 × 7·5	10·4	263	2,735·2	1·49	2·22	23·09	32·5
S	2 × 7·5	10·4	70	728	0·44	0·19	1·98	32·5
T	2 L 100 × 50 × 8 ..	23	40·7	936·1	0·73	0·53	12·19	39·2
U	2 L 65 × 55 × 7 ..	15·92	41·1	654·31	0·73	0·53	8·44	22·4
V	43·5 × 0·8	34·89	22·5	783	0·91	0·83	28·88	5,487
W	L 55 × 55 × 6 ..	6·31	2·36	14·89	1·12	1·25	7·89	17·3
—	—	1,144·42	—	130,418·12	—	—	1,805·05	465,346·6

The base is the line on the underside of the keel plates.

$$\text{Neutral axis above base line} = \frac{130,418 \cdot 12}{1,144 \cdot 42} = 114 \text{ cm.}$$

Moment of inertia (half midship section) = 18,050 500 × 465,346·6 = 18,515,846·6 cm.⁴

Furthest fibre from neutral axis = 350 − 114 = 236 mm.

$$\text{Moment of resistance (half midships section)} = \frac{18,515,846 \cdot 6}{236} = 78,457 \text{ cm.}^3$$

Moment of resistance (midship section) less 10 per cent. for rivet-holes = 78,457 × 2 × 0·9 = 141,222·6 cm.³ = 1,412 cm.² m.

Case No. 1. (See Fig. 5, page 313). Ship with 2,170 tons cargo equally divided over the holds.

Displacement = 2,570 tons. Draught = 2·70 m.
Maximum shearing force = 88 tons.
Maximum bending moment = 1,116 meter-tons.

$$\text{Compression in top} = \frac{1,116,000}{1,412} = 791 \text{ kg./cm.}^2.$$

$$\text{Tension in bottom} = \frac{791}{236} \times 114 = 382 \text{ kg./cm.}^2.$$

Case No. 2. (See Fig. 5, page 313). Empty ship.
Displacement = 400 tons. Mean draught = 0·45 m.
Maximum shearing force = 20·4 tons.
Maximum bending moment = 424 meter-tons.

$$\text{Tension in top} = \frac{424,000}{1,412} = 300 \text{ kg./cm.}^2.$$

$$\text{Compression in bottom} = \frac{300}{236} = 114 = 145 \text{ kg./cm.}^2.$$

Case No. 3. (See Fig. 5, page 313). Holds Nos. 4, 6, 7 and 9 empty. Other holds with cargo. Total cargo = 1,497 tons.
Displacement = 1,897 tons. Draught = 2 m. Ship on an even keel.
Maximum shearing force = 176 tons.
Maximum bending moment = 2,784 meter-tons.

$$\text{Tension in top} = \frac{2,784,000}{1,412} = 1,971 \text{ kg./cm.}^2$$

$$\text{Compression in bottom} = \frac{1,971}{236} \times 114 = 952 \text{ kg./cm.}^2$$

Case No. 4. (See Fig. 5, page 313). Holds Nos. 1, 2, 3, 4, 5, and 6 half loaded; holds Nos. 7, 8, 9, 10, 11 and 12 fully loaded. Total weight of cargo = 1,488 tons. Trim by stern. Mean draught = 2 m.
Maximum shearing force = 94 tons.
Maximum bending moment = 1,480 meter-tons.

$$\text{Compression in top} = \frac{1,480,000}{1,412} = 1,048 \text{ kg./cm.}^2.$$

$$\text{Tension in bottom} = \frac{1,048}{236} \times 114 = 505 \text{ kg./cm.}^2.$$

The conclusion of this statical strength calculation ought to be that the long Rhine ships may be in a rather dangerous position during loading and discharging. If such a ship should be loaded or discharged injudiciously she might soon break. Therefore, the capability of the captain is a very important condition because he is the man who has to say how the ship shall be loaded or discharged. In particular, the old way of loading ore, with the lighter lying alongside a steamer which is conveying her cargo into the lighter by ordinary steam winches, is very dangerous, because the ore is not discharged exactly in the centre of the cargo holds, thus giving the ship a trim and a list. When the ship has been half loaded and has got a considerable list she is then towed round with the assistance of two tugs to complete her loading on the other side, thus bringing her on a level keel.

The modern system of loading ore is by long horizontal loading-bridges which bring the ore nearly to the centre of the bottom of the lighter. Such cranes are employed on the banks of the Maas and Waalhaven at Rotterdam.

It is easily seen how dangerous is the twisted position of such a ship, and how it is quite insufficient to arrive at conclusions about the strength by considering only the shearing forces and the bending moments as if the Rhine ships were really a straight beam. The great danger of a Rhine ship is that she is so long and never can be constructed sufficiently stiff to eliminate the danger of buckling the bottom or the hatch coaming plates. It is for this reason that the Rhine ships are constructed with no special longitudinal keelsons on the bottom, but with more strength in the hatch coamings (or furthest fibre from the neutral axis), the sheer strake and the bilge and bottom strakes, and with a large number of 'thwartship bulkheads to give the ship a certain resistance against twisting and buckling. Strong longitudinal keelsons make the weight of the ship herself too great, and bring the neutral axis too low, so that what is gained in strength on the bottom is lost on the top of the hatch coaming plates.

The most dangerous way of loading or discharging a Rhine ship is when the hatch coaming plates are in tension while the bottom is in compression. The captain would never notice the starting or buckling in the bottom plates, therefore he always loads or discharges his ship in such a way that the bottom is in tension. As soon as he observes signs of twisting or buckling in the hatch coamings he knows that a mistake has been made in loading or discharging, and the work has to be stopped at once.

Besides this we have to pay proper attention to the local stresses, which, for instance, may be caused by putting in a heavy weight of ore at the bottom of one of the holds, which will cause such a bending of the bottom locally that the displacement and the deadweight of the ship are more than shown by calculation without deflection of keel. It has often been found after some years that the riveting of the bilge and bottom was so damaged that re-riveting was necessary. I myself once observed, when a heavy weight of copper ore was put in one of the holds too suddenly that the frames at the bilges and the bottom plates in the neighbourhood of one of the bulkheads were broken, so that the cargo fell through into the river. Nevertheless the ship remained afloat, but it was rather difficult to put her on a slipway by reason of the bottom plates hanging at an angle underneath the bottom.

Regarding the details of construction I would draw attention to the covering of the hatchways with wooden hatches; the special closing of these having regard to Custom House requirements; the construction of the bollards, never made of cast-iron but of steel plates; the steering gear which can be lowered; the anchor, windlass for hand use and, on the largest ships, driven by a small motor.

Finally, I would remark that practically all the river ships in Holland are built of steel, wooden ships having died out. Experiments have also been made with ferro-concrete. A few years ago I was charged with the inspection during building in Germany of four ferro-concrete Rhine lighters. The results were so bad that I had to refuse to accept them, and I believe it is not too much to say that ferro-concrete river ships have no future at all. The reasons are that if the ship has been built strong enough for the general shearing forces and bending moments she is much heavier than a steel ship, so that the deadweight carrying capacity is much less; nevertheless, she will never be strong enough to resist local collision damage which appears to be of daily occurrence in this trade.

THE WATER-TIGHT SUB-DIVISION OF PASSENGER SHIPS.*

Notes on the Curves and Formulæ for regulating the Water-tight Sub-division of Passenger Ships.

By Sir ARCHIBALD DENNY, Bart., LL.D. (Honorary Vice-President).

IN May, 1912, following the Titanic disaster, the British Board of Trade appointed a committee to consider the water-tight sub-division of all ships. Previous committees in Great Britain had dealt with sub-division, notably that of 1890–91, but, so far as is known, in 1912 water-tight sub-division throughout a ship on any system depending upon flooding curves was not required by official regulations in Great Britain or in any other country, with the exception of Germany, where, following the sinking of the Elbe, rules under the See-Berufsgenossenschaft were enacted and put in force. These rules divided passenger ships into two classes—(1) fast steamers, *i.e.*, those of fine form and great speed, which serve almost exclusively for the transport of passengers and, in proportion to their size, carry little cargo, and (2) cargo and passenger steamers, *i.e.*, ships of moderately fine or of full form, of moderate speed, which carry large quantities of cargo and besides that, as a rule, more than 50 passengers.

The grading in each class (1) and (2) was in one and two-compartment steps and on the assumption of increasing permeabilities as the ships increased in length. There was no fixed criterion of service to distinguish the two classes, nor was there, so far as is known, any intermediate grade between the two classes.

So long as only one nation had such rules and the two classes were found to be distinctly separate, this system, when applied in a reasonable manner by a capable and independent authority, would produce fairly good results. Many of the German passenger ships which were built under these rules are now in the hands of different nations, and the practical effect of the application of the rules can therefore be ascertained independently. It is understood that the "cargo and passenger" ships have been found to be sub-divided in an orderly fashion and are generally at least "one-compartment" ships, but, without the particulars of the lines, &c., it has not been possible to make a full comparison with the Convention system of grading. The "fast steamers" have been found well sub-divided, except that in some cases very free use has been made of long steps and recesses in the decks and bulkheads when the exigencies of passenger accommodation required them.

The 1912–15 Bulkhead Committee was supplied with copies of these regulations, and naturally took them into account when making its preliminary investigations. It was also supplied with a memorandum drawn up by the Board of Trade's Principal Ship Surveyor, in which he asked that all suggestions should be accompanied by data of such a nature that they could be simply and accurately applied. He indicated that this had not been so in the case of the curves supplied by the 1890–91 Committee. The 1912–15 Committee, therefore, formed a staff at Newcastle under one of its members which, after about two years' labour, produced the flooding curve diagrams and other particulars by which true flooding curves are quickly and conveniently obtained for any ships but those of extraordinary design. The object of doing so was two-fold (1) to meet the wish of the Board of Trade staff as expressed above, and (2) to admit of the committee examining quickly a large number of typical ships so that they might have actual figures to guide them in making their final recommendation as to sub-division.

While the above work was proceeding, the committee was generally occupied in taking evidence in regard to accidents which had led to flooding; the effect on bulkheads as then constructed; the effect of openings in the bulkheads, sides and decks and the methods of closing them; longitudinal sub-division; and many other details, for particulars of which see Chapter II of the committee's report. On that evidence and on other investigations were based the details of construction embodied in the two reports of the 1912–15 Committee, on which no very serious criticisms have been made.

Returning to the work done by the staff at Newcastle on the geometry of the problem, the flooding curve diagrams were practically finished about the end of 1913 and the committee took up in detail the consideration of the standards of sub-divison to be recommended, a matter which had previously been discussed only in a general way. With their knowledge of the German

* Paper read at the Summer Meeting of the Institution of Naval Architects, held in Holland, September 3, 1923.

system, combined with the evidence taken and their own knowledge of many types of vessels, it had been decided that the severity of sub-division should increase gradually and continuously from a one-compartment to a two-compartment standard and should then gradually approach a three-compartment standard for the highest class. But at the end of 1913, when the Board of Trade asked for a memorandum for the purpose of instructing the British delegates at the approaching International Conference on the Safety of Life at Sea, the committee was not far advanced in the investigations of sub-division, as the flooding curves diagrams had not been available for a sufficient time for them to be applied to a large number of typical vessels.

As to what is now known as the "Criterion of Service" which would govern the grading of vessels, this had been considered in a general way and certain investigations had been made taking into account the number of passengers, but it was thought then and confirmed later that this alone would be an unsuitable criterion, for the reason that it would tend to segregate ships into pure passenger and pure cargo ships which would be against the public interest. Nothing at all on the subject was, therefore, included in the memorandum to the Board. The investigation of the permeability of different cargoes, machinery and other spaces which was necessary for the system of sub-division which the committee had provisionally adopted had, however, been carried out, with the result now known, and the figures arrived at, as being average ones, have not been seriously challenged.

The above outlines the position of affairs at the end of 1913 when the Conference on the Safety of Life at Sea first met, and it is not necessary to deal in detail with the Convention which was ultimately signed in London by the delegates, but which has not yet received complete international agreement. Reference is made to page 7 of the first report of the 1912–15 Committee for a short note on the work of the Convention and a description of the results and generally how they were arrived at.

In regard to the French system, it should be added that it not only included the factorial method, but also embodied a "criterium" and the expression "criterion of service" was, it is believed, suggested by the French delegation and accepted by the Convention Committee dealing with sub-division. The work of the 1912–15 Committee was not sufficiently advanced to permit of the British delegates offering a complete and definite scheme, nor were the French delegates in a position to do so, while the German delegates submitted the rules of the See-Berufsgenossenschaft as their proposals for adoption, noting when doing so that they had had 17 years' experience. That was a very strong "gesture."

The three systems proposed had this in common, that the severity of sub-division increased with length of ship, but it is to be noted the German system was a series of steps. Personally, the author still thinks that the British proposal of visible and increasing margins, after flooding, had great advantages, notably in connection with the arrangement of openings in the sides and bulkheads as referred to on page 8 of the first report, but the factorial system had the same practical effect in grading the severity of sub-division in a gradual and continuous manner. The method of tracing the two factor curves B and C was originally suggested by the Belgian delegates who proposed to combine the French factorial system with the British permeabilities and proposed a series of factors for different lengths. This was accepted in principle and was then linked up with the German "severity of sub-division" in the curves B and C at the suggestion of the French delegates, who worked by a method of comparison using assumed permeabilities for a particular part of the ship in relation to the specified permeabilities of the German rules.

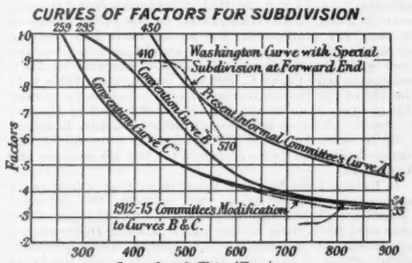
Certain points were left over by the Convention for national investigation such as the Criterion of Service, longitudinal and horizontal sub-division; sub-division of small ships and the strength and construction of bulkheads, &c. The British Government was invited to undertake the duty of circulating the information when obtained, and the 1912–15 Committee was asked by the Board of Trade to make proposals on these points with as little delay as possible. So far as is known, no information was received by the British Government from other Governments up to July 29, 1914, when Dr. Welch, Mr. Carter, the Secretary of the Committee, and the author proceeded to Paris and attended a conference with representatives of Belgium, France and Germany and submitted to them the committee's suggestions on a Criterion of Service and other points. The war, which followed in five days, stopped all international work on this matter and the committee completed its work with all speed. This work was very largely based on and controlled by the Convention and was carried out under great difficulties, as the energy of the members was necessarily devoted to the production of munitions of all kinds to meet the national needs.

Special attention is drawn to the 1912–15 Committee Report where it deals with the strength and construction of bulkheads. Very wisely our Government completely met the committee's request that funds should be placed at its disposal for the purpose of making full-sized tests, and in doing so the Government rendered a service of the greatest value to all nations, which, it is believed, will lead to the settling of this question in a satisfactory manner. On receipt of the committee's first report, dated November 3, 1914, the Board of Trade decided that our Government, having ratified the Convention, was in honour bound to do what they could, pending final international agreement. It was not possible to carry out the Convention fully as, for example, no Criterion of Service, an essential feature, had been agreed to, nor had any of the other points left over for consideration been internationally discussed or accepted.

The Board took the view that they were bound by Article 16 of the Convention dealing with existing ships to make the best arrangements possible, and, therefore, ruled that new passenger ships should comply with the Curve B standard of sub-division, and as an optional regulation said further that, if owners desired it, they might use the Criterion of Service suggested in the committee's report if they wished to interpolate between Curves B and C. Construction of passenger ships in the United Kingdom was practically at a standstill during the war, but a period of great activity set in after the armistice, and owners of intermediate steamers at once complained that Curve B was too severe for that class of ship and pointed to Article 17 of the Convention, which states that "ships shall be as efficiently sub-divided as is possible having regard to the nature of the service for which they are intended," and claimed that it was not the intention of the Convention to make impossible the construction of ships similar to those of existing serviceable types.

A paper was read before a meeting of this institution by Sir Westcott Abell in Liverpool, in 1920, which followed a general paper on "Odds on for Sinking" read by him before the Royal Society. Starting with the probable length of damage due to torpedo explosion, he claimed that bulkheads too closely spaced might increase instead of diminish the chance of sinking, and suggested a reversion to plain one- and two-compartment sub-division with certain grading. It was pointed out in the discussion that such lengths of damage were a great rarity in ordinary peace times, and it was considered that the factorial system was the better one and was fairest as between ship and ship. In 1920 a small British deputation visited the United States of America and had an informal discussion at Washington on the sub-division situation in particular relation to the intermediate type of ship and, as a result, an alternative system was published by the Board of Trade in Circular No. 1623. Consultation also took place with the French experts on this and other matters dealing with the putting into force of the Convention.

The alternative system permitted the longer holds forward of the machinery spaces so essential for the ordinary intermediate steamer, but as a *quid pro quo*



called for additional sub-division at the forward end. This had some beneficial results in certain steamers, but the call continued for a less severe starting point than that imposed by Curve B or the above-mentioned alternative, and the Board of Trade asked the shipowners to formulate their own proposals. This they did in a general way, based on a similar system to that outlined by Sir Westcott Abell and referred to above. The department then invited Mr. Foster King, Dr. Welch and the author to join with Sir Herbert Rowell, Sir Westcott Abell and Mr. Colvill, to consider and advise as to what should be done. The former three were members of the 1912–15 Committee and the three latter were those who had been at the Washington Conference.

It appeared to this Informal Committee, as a result of their investigations, that the statements of the shipowners had a substantial foundation and that the 1914 Conference, in fixing the factors for Curve B, had not sufficiently taken into account that type of ship, which is practically a cargo ship, carrying a limited number of passengers as an adjunct only. But, as the British figure of more than 12 passengers was adopted in the Convention as the limit when a ship was to be considered as a passenger ship, all ships carrying 13 or more passengers, whatever their type, were immediately forced to adopt at least Curve B factors. The Informal Committee then made careful inquiry as to the minimum length of main hold which would not unduly hamper cargo ships of about 440 ft. in length, the most common type of intermediate steamer in ocean service, and decided upon about 80 ft. as reasonable.

It will be noted that Curve B is one of contraflexure and in this differs from Curve C. The Informal Committee saw no reason why a properly situated initial curve, such as that ultimately submitted for acceptance as Curve A (see diagram above, should not be of the same character as Curve C. The difficulty after providing a new starting point in Curve A was to evolve a suitable Criterion of Service and to that the Informal Committee devoted a great part of their time. The Informal Committee laid down Curve A as applicable to the ship which is practically an ordinary good type of cargo ship having a poop, bridge and forecastle covering about six-tenths of her length, carries no passengers below the bulkhead deck but has a limited number above and may be loaded to the full load draught permitted by the freeboard tables. The appended diagram shows the relation of Curve A to the Convention Curves B and C, and to the curve indicating the interpretation of the Washington Informal Conversation which resulted in the publication of the alternative system mentioned above. It will be noted that the Curve A cuts the line of factor of unity at 430 ft. length and as 330 ft. is about the smallest present-day overseas passenger ship, it has been proposed that ships of less length than 330 ft. should be dealt with by national regulations only, as provided for by Convention Article III.

In the course of the committee's investigations, it was learned that certain designers were strongly of opinion that Curve C was altogether too severe for any ship and that Curve B was sufficient even for the highest class of passenger ship. It was also claimed by shipowners that nothing further was required in any case for any ship than that she should be an undoubted "two-compartment ship." The Convention did not call for a smaller factor than 0·34 and that only at 899 ft. The 1912–15 Committee called for a 0·33 factor at 800 ft. but definitely called for nothing more severe (see diagram). Whether, as is claimed, Curve C is too severe must be a matter of opinion after investigation, but it is known that shipowners of certain nations have, since 1914, constructed some ships to conform to Curve C, and even in excess of its severity.

It was expected by the 1912–15 Committee that the result of the regulations would be to increase the freeboard ratios in passenger ships, that is to say that new ships would probably be deeper in proportion to their length. Experience shows this to be more pronounced than was anticipated and, in extreme cases, has resulted in a type of ship having long holds associated with extra 'tween decks devoted to passengers below the bulkhead deck. In the opinion of the Informal Committee such extreme development was undesirable and pointed to the need of a modification of the regulations ensuring more normal design. It was the consideration of these points which led the Informal Committee to make the proposal that Curve A should govern the sub-division of the most cargo and least passenger ship.

In December, 1921, on the invitation of the Board of Trade, an Informal Conference, attended by experts from the United States, France, Belgium and Great Britain, met in London and discussed the position. Curve A was submitted by Great Britain, and proposed forms of Criterion of Service were submitted by the United States, France and Great Britain, the broad principles of which may be understood from the following descriptions:—

America.—For a ship of given length, loaded to the draught given by the freeboard tables, the number of transverse watertight bulkheads was to be regulated by the total number of passengers carried. This was indicated in a table and also more completely by a diagram. In cases where the number of watertight bulkheads fitted differed from these requirements, an adjustment of the freeboard was provided for in accordance with a specified rule. Under this scheme the factorial method would be dispensed with, the spacing of the watertight bulkheads being left to the discretion of the designer and only restricted by the definite requirements of Convention Articles IX and XI.

France.—The length, draught and paying deadweight of a ship were combined in a criterion formula from which a numeral could be obtained and used for interpolating between the higher and lower limiting standards of sub-division to which suitable numerals were to be assigned for this purpose.

Great Britain.—A scheme of sub-division was put forward embodying a criterion formula based upon the mean permeability of the ship below the bulkhead deck, to which was added a correction to allow for the space occupied by passengers accommodated above the bulkhead deck. This formula gave a criterion numeral to be used for interpolation between the limiting curves A and C, to which were assigned definite numerals.' Agreement upon any one of these proposed criteria was not found possible, but it was decided that the criterion should take account of the passenger function, and the power or speed function, and, finally, it was thought best to draw up a combination formula from which each delegation was to start further investigations. It should be stated that the British submitted Curve A, not only as a drawn curve, but defined by an equation, and they proposed a similar equation for a Curve C. The provisional formula which was to form the basis of further investigation was as follows:—

$$C_s = \frac{L}{f.B} + 60\,\frac{(P + M)}{W}$$

C_s = Criterion numeral.
L, B = Length and breadth of ship in feet respectively.
f = Block co-efficient of displacement.
P = Volume of permanent passenger accommodation above and below the bulkhead deck.
M = Volume of that portion of the machinery space which is occupied by the main and auxiliary propelling machinery and is necessary for the proper working of that machinery.
W = Total volume of ship above and below the bulkhead deck.

Curve A was accepted as the starting point and the criterion numerals to be associated with Curves A and C were $18\left(1 + \frac{100}{L}\right)$ and 75 respectively, the former providing for a limited number of passengers given by $\frac{L^2}{1000}$ taken for this purpose at 250 cub. ft. per passenger.

While the questions of Curve A and the criterion were the principal subjects discussed, agreement was arrived at between the four delegations on other important amendments to the Convention as follows:—

(*A*) *Amendments definitely recommended.*—All permanent coal bunkers to be included in the machinery spaces and separated from the cargo spaces by watertight bulkheads and casings. Unless a compartment was at least 2 per cent. of the length, plus 10 ft., it should

not be counted as part of the scheme. The special mark for exceeding the specified sub-division should be applicable to all ships, but only *if the length of the comparative vessel is at least equal to the length of the actual vessel plus 5 per cent.* The fore peak, while not to be less than 5 per cent. of the ship's length, should not exceed this length by more than 10 ft.

Rules for the additional sub-division at the forward end of all ships and the drawing of the margin line for the purpose of sub-division in cases where the bulkhead deck is discontinuous, were also recommended.

(*B*) *Amendments recommended in principle* subject to modification that may be necessary as a result of (*C*):—The marking of the sub-division loadline, including provision for alternative lines when some of the spaces are allocated alternatively to passengers or cargo. Special consideration as regards sub-division of machinery spaces, including tunnels, in which no watertight doors are fitted below the loadline. A revised method (Article VII) of estimating the mean permeability of the ends and machinery spaces in connection with the flooding calculations.

(*C*) *Questions for further study* and the course to be pursued:—The important matter of the Criterion of Service, which is dealt with above. The British method of calculating the floodable length was recommended to the other nations as the standard method, subject to each interested nation retaining the right to adopt a different method so long as it is equivalent to this standard method. Also, that a method shall be considered as equivalent to the standard method provided that, if applied comparatively with the standard one, the resulting flooding curve shall have the same ordinates throughout its length within a tolerance of 2½ per cent. either way. It was recommended that the strength and stiffening of transverse watertight bulkheads, steps and recesses shall be in accordance with the requirements of a recognised classification society or an approved equivalent, for a head of water above the bulkhead deck 20 per cent. of the distance from the middle of height of the bulkhead stiffener to the bulkhead deck, or for a head of 4 ft. above the bulkhead deck, whichever is the greater. Suitable tables were to be prepared on this basis and circulated by the British Government.

As noted above, this further work on the bulkhead scantlings was entrusted to the British and was duly carried out by the Informal Committee. It was finally transmitted to their foreign colleagues in the form of tables and letterpress as having been agreed by the Board of Trade, Lloyd's Register, the Bureau Veritas and the British Corporation. As these three latter bodies are in close relationship with the classification societies of several other nations, it is thought there will now be no difficulty in reaching international agreement on that point. The Informal Committee then took up the investigation of the provisional criterion formula given above. It was thought that the first term, which was intended to express in some sense the speed factor, was rather insensitive and not sufficiently or accurately qualitative, hence the committee came to the conclusion that it would be better to omit it and that this could safely be done as the second term contained a good power factor in M, and the block co-efficient would be reflected in W.

The study of the complete provisional formula showed that the highest value of C_s found by applying it to the British fastest and largest, practically exclusively passenger vessels, did not much exceed 60. A study of the second term showed that even in a completed vessel it was difficult to ascertain the value of M as defined, and that of the other volumes anything above the bulkhead deck was equally difficult to fix absolutely, while it is apparent that the system shared disadvantages which were stated by critics of the 1912–15 Committee's criterion to be inherent to it. These included the criticism that it seemed unreasonable to place accommodation above and below the bulkhead deck in the same category or to call for closer bulkheads or decreased draught because an owner at the last moment of design or construction decided to enlarge certain public rooms situated above deck without increasing the number of berths fitted.

A serious attempt was made to develop it in its stated form and a number of actual ships were first arranged by careful inspection in a graded list of most cargo and least passengers to most passengers with practically no cargo. From full particulars obtained, especially from owners and builders, the formula was then tested with, in the Committee's opinion, unsatisfactory results. These and former investigations disclosed that both from a "service" and a "safety" point of view, the part of a ship below the bulkhead deck was the most important and that, so far as a Criterion of Service based upon space ratio was concerned, the actual volume of superstructures might be ignored. For this reason, and also on account of the difficulty of correctly estimating the volume of the superstructures in the early design stage, it was decided to base the space ratio upon the allocation of space below the bulkhead deck, keeping, however, the same form of expression as the second term of the conference formula. It was found by actual trial that for comparative, *i.e.*, criterion purposes, the machinery function is expressed with fairness by the volume of the machinery portion of the ship defined in Convention Article V.

As to the passenger function, this was found to be given equitably by the volume of the accommodation below the bulkhead deck, provided the total number of passengers carried did not exceed a certain limit beyond which a correction was necessary. This led to the proposal by the department's experts of a "specific volume per passenger," for criterion purposes only it should be observed, and as the result of a careful examination of many existing passenger ships of all types, 0·6 L cub. ft. was adopted as representing good average practice. In arriving at this figure all classes of passengers and the whole of the accommodation above and below the bulkhead deck were taken into account.

$$C_s = 72\left(\frac{M + 2P_1}{V + P_1 - P}\right) \quad . \quad . \quad (1)$$

$$C_s = 72\left(\frac{M + 2P}{V}\right) \quad . \quad . \quad . \quad (2)$$

Working on the lines already indicated the criterion formulæ (1) and (2) given above were evolved.

C_s = Criterion numeral.
L = Length of ship as defined in article V.
M = Volume of the machinery space portion of the ship as defined in article V.
N = Total number of passenger berths in ship.
P = Volume of passenger and crew spaces below the bulkhead deck as defined in new article VII. (*See* Appendix A.)
$P_1 = N \times 0{\cdot}6\,L$.
V = Whole volume of ship below the margin line.

When P_1 is greater than P, formlua (1) is used and in all other cases formula (2) is operative.

The ordinary "three island" ship of the cargo type carrying $\frac{L^2}{1{,}000}$ passengers above the bulkhead deck was used in estimating the limit numeral 23 for Curve A.

As regards the limit numeral for curve C, the Aquitania and Mauretania were taken as representative of the type of ship to which the Curve C standard of sub-division might apply, and the numeral 123 was derived from the relevant particulars furnished by the owners of these ships. For the co-relation of the terms M and P in the formula the co-efficient 2 applied to the latter was found to give a fair balance between these two functions as indicated by the graded list of ships above mentioned. The scale factor 72 was chosen to give for convenience a scale range of 100 between curves A and C.

These formulæ have been tried on many ships representative of all types and services and found satisfactory. The result of these investigations of the provisional criterion formula and the British proposals based thereon were in June, 1922, transmitted to the other delegates to the 1921 Conference, but so far there has been no agreement on this question. It should be here observed that with the Conference formula a numeral of 75 is associated with Curve C, but this is not comparable with the 123 of the British formula and it is necessary to keep this in view when comparing results obtained by the two methods. A fairer comparison may be made, however, if 60 be substituted for the Conference numeral 75, the former being the figure obtained for the Mauretania and Aquitania.

It having been borne in upon them that a four-party agreement on a criterion was unlikely, the Informal Committee reported to the Department at the end of last year and gave their advice that, pending International agreement on a Criterion of Service, their proposed modification of the 1921 Conference formula might be used by the British. It is impossible to say what course would have been followed in connection with international action had the war not occurred, but the Convention foresaw that there would certainly require to be some modification of its conditions as experience was gained, and therefore made provision for such modification during its currency and also at the end of each five-year period. There should then have been a Conference in 1919, but the war prevented that taking place, and no settlement of an international criterion seems to be yet in view, and, failing this, the full terms of the Convention cannot be properly applied internationally.

When the Informal Committee's first report was handed to the Department the latter sent it to the shipowners and invited their opinion. This the shipowners gave in writing and the Department then invited the shipowners and the Informal Committee to meet with the Department and discuss matters. This meeting took place in the latter part of last January. The shipowners broadly put forward two principal points; (1) that Curve A was not sufficiently far to the right, and that, instead of cutting the factor of unity line at 430 ft., it should not do so until 460 ft., and (2) that Curve C should be cut off by a horizontal line at 0·45 factor, maintaining however, the lower part of Curve C for interpolation purposes. This they claimed would ensure an undoubted "two-compartment" ship beyond which they thought nothing more was necessary. They drew attention to the modern practice of fitting watertight compartments for oil fuel sometimes along the sides of the entire machinery space, and urged that the buoyancy of these when the ship had been holed by collision should be specially taken into account, and, further, they urged the additional security which these gave as a system of longitudinal sub-division when fitted continuously along the sides of the machinery spaces.

The shipowners asked if it was proposed to continue Curve C indefinitely by the formula above 900 ft. in length. By an actual design of a ship of the most passenger and least cargo type fitted with these longitudinal side oil bunkers they illustrated the difficulty of design at about the midship half length and of providing efficient arrangements for marshalling the emigrants in a safe and orderly fashion to the boat deck. The Informal Committee studied these points and made a second report to the Department. In this report they adhered to Curve A. As to Curve C they suggested that, pending final international agreement, the Board might adhere to the Convention Curve C and that no smaller factors than 0·45 and 0·34 should be required for the Curve A and Curve C standards respectively.

As to the shipowners' suggestion that the oil bunkers might be taken into consideration, both as longitudinal protection and as specific buoyancy, the Informal Committee drew attention to the provision for longitudinal sub-division embodied in the 1912–15 Committee's report and made certain suggestions. The Informal Committee was of opinion that the principle of the concession in transverse sub-division suggested by the 1912–1915 Committee might be extended upwards beyond the limit of the 0·45 factor, the relaxation decreasing as the factor increased to unity, when it would vanish. They stated, however, that the variation in design of these oil fuel compartments as to position, and extent upwards and inwards, was so great that each case would require to be specially considered, applying, however, a limiting angle of heel when probable damage was considered and assuming that if certain tanks were damaged on one side, the corresponding compartments on the opposite side were to be assumed as flooded to adjust the heel and hence be out of action as buoyancy. As the number of ships concerned would necessarily be limited and would in any case require special consideration, no objection, it is thought, can be raised to this until experience is gained by practice.

APPENDIX A.

RECOMMENDED NEW ARTICLE VII. CONVENTION REGULATIONS.

PERMEABILITY.

The definite assumptions referred to in Article VI relate to the permeabilities of the spaces in question below the margin line.

In determining the floodable length, a uniform average permeability shall be used throughout the whole length of each of the following portions of the ship:—

(1) The machinery space.
(2) The portion forward of the machinery space, and
(3) The portion abaft the machinery space.

(i) For steamships having no between deck spaces in way of the machinery space, the uniform average permeability of the latter is to be taken at 80; but in those having one or more between deck spaces in way of the machinery space the uniform average permeability is to be obtained from the formula:—

$$75 + 12{\cdot}5\frac{a}{v}$$

Where a = volume of the passenger and crew spaces between decks (as defined in paragraph IV), which are situated below the margin line within the limits of the machinery space.

v = whole volume of the portion of the ship below the margin line within the limits of the machinery space.

For ships fitted with internal combustion engines, the uniform average permeability of the machinery space shall be five greater than ascertained by the above rule for steamships.

(ii) The uniform average permeability throughout the whole length of each portion of the ship forward or abaft of the machinery space shall be obtained from the formula:—

$$63 \times 35\frac{a}{v}$$

Where a = volume of the passenger and crew spaces between decks (as defined in paragraph IV), which are situated below the margin line forward or abaft the machinery space as the case may be.

v = Whole volume of the portion of the ship below the margin line forward or abaft the machinery space as the case may be.

(iii) If, in a between deck space enclosed by complete permanent steel bulkheads, any portion thereof is appropriated to passengers, the whole of that space shall be regarded as passenger space.

(iv) Passenger and crew spaces between decks are those which are neither specifically appropriated to nor to be used as cargo spaces, main and auxiliary propelling machinery, or other machinery spaces, bunkers (permanent, reserve, or oil fuel), store-rooms, baggage and mail rooms, chain lockers, watertight tunnels, fresh water tanks and peak or other tanks.

APPENDIX B.

EXTRACT FROM THE PROPOSED NEW ARTICLE VIII. CONVENTION REGULATIONS.

British proposed scheme of sub-division using the Criterion of Service formulæ and limiting numerals given on page 315.

(*a*) The sub-division of all vessels 430 ft. in length and upwards having a criterion numeral of 23 or less shall be governed by the Curve A factors; those having a criterion numeral of 123 or more by the Curve C factors and those having a criterion numeral between 23 and 123 by factors obtained by linear interpolation between Curve A and Curve C.

(*b*) In the following:—

$$S_1 = \frac{9382 - 20L}{34} \qquad S_2 = \frac{8267 - 20L}{29}$$

$$S_3 = \frac{7152 - 20L}{24} \qquad S_4 = \frac{6037 - 20L}{19}$$

(i) Ships less than 430 ft. but not less than 260 ft. in length having a criterion numeral equal to S_1 shall be sub-divided abaft the fore peak using the factor of sub-division unity; and those having a criterion numeral between S_1 and 123 shall be sub-divided abaft the fore-peak using a factor of sub-division obtained by linear interpolation between unity and the factor C.

(ii) Ships less than 430 ft. but not less than 235 ft. in length having a criterion numeral less than S_1, but not less than S_2 shall be so sub-divided that neither the

combined length of the fore peak and the adjacent compartment nor the length of any other compartment forward of the machinery space, nor the length of the aftermost compartment exceeds the floodable length; nor shall the length of the aftermost compartment be less than 80 per cent. of the floodable length.

(iii) Ships less than 380 ft. but not less than 210 ft. in length having a criterion numeral less than S_2 but not less than S_3 shall be so sub-divided that neither the combined length of the fore peak and the adjacent compartment, nor the length of the second compartment abaft the fore peak, nor the length of the aftermost compartment exceeds the floodable length; nor shall the length of the aftermost compartment be less than 80 per cent. of the floodable length.

(iv) Ships less than 330 ft. but not less than 185 ft. in length having a criterion numeral less than S_3 shall be so sub-divided that neither the combined length of the forepeak and the adjacent compartment nor the length of the aftermost compartment exceeds the floodable length.

(v) Ships less than 280 ft. in length having a criterion numeral less than S_4 shall have a fore peak not exceeding in length the floodable length assuming a permeability of 100 per cent., nor less than 80 per cent. of that length, and shall have an aftermost compartment of length not exceeding the floodable length.

THE SUB-DIVISION OF LARGE PASSENGER STEAMERS.*

By MR. A. C. F. HENDERSON, Associate.

THIS paper is intended as a statement of the position from the shipowner's point of view of large passenger steamers in relation to present and possible future subdivision regulations. The Convention of 1914, the rulings of which have been in force in Great Britain only, has proved itself in the light of experience to have imposed restrictions on the development of sea-borne trade in precisely the manner which it was intended to avoid. There is nothing specially remarkable in this, as the decisions made at that time no doubt were influenced by the proximity of one of the greatest marine disasters of all time—the loss of the Titanic. During the last few years, as a result principally of the agitation made by British shipowners, much time and trouble has been devoted to the task of recasting the rules for the subdivision of ships, so that the Convention may be modified in such a manner that economic restrictions will be removed and standards adopted which will be acceptable to, and made operative by, all the principal maritime countries of the world.

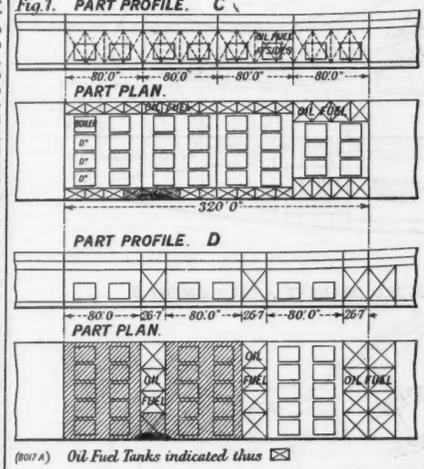
In order to obtain the proper mental perspective it is necessary to recall briefly the recent events which have led up to the present situation. The first step towards a reform was a conference held at the British Board of Trade in October, 1921, at which shipowners were invited to put forward a scheme which would provide a standard of safety at least higher than that existing before the Titanic disaster, and also remove the disabilities which had resulted for the time being in almost a complete cessation of passenger shipbuilding in Great Britain.

Previous to this, in May, 1920, an Informal Conference had been held in Washington, U.S.A., to discuss the whole question of subdivision, the result of this conference being the adoption as an interim measure of a partial scheme which gave relief to a limited class of vessel of the intermediate type. The next step—the details of which are widely known—was the International Shipping Conference held in London in November, 1921, at which a committee was appointed to consider and report on the manner in which the Convention should be modified. This committee commenced its work in May, 1922, and was composed of technical experts from all the principal maritime countries. Concurrently with all this work an Informal Committee on bulkheads and watertight subdivision appointed by the President of the British Board of Trade in December, 1920, had been consulting upon the criterion of service and other cognate questions. The work of this committee has not yet been made public, so it is not possible to make detailed reference to it. It will suffice, however, to say that the recommendations made in their first report, dated November 15, 1922, supplied ample evidence that the considered opinions of the International Committee of 1921 had been almost completely disregarded. This attitude threatened to have the most serious effect on the future construction of large fast passenger steamers of the highest type. It was this aspect of the question which prompted me in the early part of this year to offer to read at the Spring Meeting of this Institution, held in London, a paper pointing out the inherent difficulties of formulating hard and fast rules for the subdivision of large passenger vessels, without fully appreciating the effect of such rules on the earning capacity of the resultant ships. The Council, however, decided that the time was inopportune for public discussion on the subdivision question, and it was not for me to criticise the wisdom of their decision.

As a result of action taken by the British Chamber of Shipping the Board of Trade invited the British members of the International Subdivision Committee to meet the Informal Committee and discuss their report. On April 4, 1923, the Informal Committee completed their second report to the President of the Board of Trade. As a result of the discussion in January the standard recommended therein for large passenger vessels showed some signs that the practical economic conditions had been given more consideration than was indicated in their first report, but it still fell very far short of what was held to be reasonable and possible by the shipowners. So far as the intermediate types are concerned their proposals allow sufficient latitude in regard to draught and length of hold in all but a very few cases, but it may be remarked that an unnecessarily retrograde step seems to have been taken in recommending a standard which in some measure is more severe than the alternative method which resulted from the Informal Conference at Washington. It is in view of this not entirely satisfactory state of affairs that I would like to offer a few remarks from the shipowner's point of view.

To an unprejudiced observer there must occur the thought that the problem presented can be solved satisfactorily in two ways, whether in one or the other depending entirely on the point of view from which the solution is attempted. The shipowners' attitude is that any modification of the Convention rules for subdivision must provide for a big improvement on pre-war practice but should avoid dealing in standards with which no State in its capacity as guardian of the travelling public need concern itself. It is their belief that such a policy is the most likely to result in international application of a revised Convention, which is an object to which they attach the greatest importance as the only method of maintaining a high standard of shipping generally and of producing fair competition amongst all nations. They have expressed the opinion that the highest standard which should be made obligatory by law should be a two-compartment standard with a 10 per cent. margin for contingencies, and, in addition, for ships over 650 ft. in length, the bow protection afforded by arranging the first three compartments within the floodable length. The British Bulkhead Committee of 1912-15 recommended an upper limit corresponding to a 0·33 factor of subdivision for all ships 800 ft. or more in length, *i.e.*, on the assumptions made, a three-compartment standard throughout.

Fig. 1. PART PROFILE. C



(8017 A) *Oil Fuel Tanks indicated thus* ⊠

The Convention limit was 0·34 at 899 ft., but the Informal Committee, which includes among its members several of the original Bulkhead Committee, beat all records by proposing to abolish higher limits altogether and continue the curve according to a formula which produced a factor of 0·275 at 1,000 ft. It would be interesting to know on what grounds this proposal was made, or how such a ship could ever be operated.

It may be argued by many that the shipowners in recommending a factor of subdivision of 0·45 in place of 0·34 are trying to sacrifice a high standard of safety to save their pockets or, expressed in a more charitable form, in order to provide the public with cheaper travelling facilities. This is not so. They maintain that the ship built to a 0·45 factor is as safe as one built to a 0·34 factor, and in the absence of any absolute standard with which to make comparisons this contention cannot be disproved. The Bulkhead Committee in 1912–15, and now the Informal Committee, to all appearances have recommended standards for the big ship which have been evolved by extending a mathematical formula. It is perhaps true that they had no option, but it still remains to be pointed out that they have been working on an unsound foundation. What must be emphasised is that the factor 0·34 of the Convention is wrong, and if it be shown to be wrong economically, just as the B curve of the Convention has been shown to be wrong, then now is the time to alter it.

I am endeavouring to state the case for the large passenger vessel because although such vessels are, and probably will be, few in number, at the same time they form an important integral part of the merchant fleets of the world. The difficulty of producing an economical design for these ships involves different problems from those appertaining to ships which partly depend for their commercial success on the carriage of cargo. In the latter case success or failure as a commercial and national asset depends on facts which can be easily demonstrated. In large passenger steamers conditions are entirely different, as the features of design which combine to produce a successful ship cannot readily be defined or expressed in set terms. The deadweight that has to be carried does not vary appreciably from voyage to voyage, and the draught which, in the largest types at any rate, has to be the maximum possible, is limited by shallow water in harbour entrances. If the draught is fixed the ship with the wider spacing of bulkheads will require to have the greater bulkhead depth if both are to conform to the same standard of subdivision. Alternatively, additional bulkheads would involve increase in cost in respect of steel work, watertight doors, escape ladders and trunks, &c., and also embarrass the designer in arranging the statutory number of davits between the closer spaced hatches. But over and above this, which in itself is bad enough, is the fact that increase in depth to bulkhead deck means increase in the volume of space above the crown of the boiler-rooms which can be devoted to no useful purpose whatsoever, but on which dues have to be paid, and even more important is the inevitable increase in the total depth of the ship. As it is, the present big ships are very high out of the water; and quite apart from the obvious stability objection any further increase which must ensue if the same accommodation is to be provided with the increased depth to bulkhead deck will still further aggravate the difficulty of arranging for efficient handling of the ship's lifeboats in case of emergency. The efficient handling of lifeboats in these large vessels and the necessity for doing so is one of the most serious problems on the large modern liner. It is obvious, therefore, that any increase in severity of subdivision over and above the minimum reasonably consistent with safety must be avoided. Its effect is of far more than paper significance, and can be fully appreciated only by those with long experience of the difficulties of design and management of big ships.

It has been the considered opinion of all those bodies which have been investigating the subdivision question that the advantages of the factorial system of subdivision outweigh its disadvantages. From some points of view it is an irrational system, but at the same time it provides a convenient medium for the operation of a criterion of service. The factorial system depends for its *rationale* on an increase in reserve of buoyancy after damage as the length of ship increases and as the type approaches the purely passenger vessel. This is only true if the damage sustained is not sufficiently widespread to lay open to the sea more than the floodable length. Consideration of this fact shows that a decrease in factor does not necessarily lead to a corresponding increase in immunity from disaster. In very large ships the importance of surviving primary damage becomes, by reason of the large number carried, of greater relative importance than in smaller types. In other words, the most desirable feature in big ships is not so much the provision of reserve of buoyancy after damage as avoidance of the total destruction of reserve of buoyancy when the accident occurs, *i.e.*, a good compartment standard should be the underlying principle to have in mind when framing regulations for the spacing of bulkheads in ships of this type. In the 1914 Convention the highest standard deemed necessary for any type of ship was indicated by a factor of subdivision of 0·34. This factor was associated with primarily passenger-carrying vessels of 900 ft. or more in length. On the assumptions made this represented slightly less than a three-compartment standard or, it might be inferred, an extremely good two-compartment standard. It is, as I have already stated, obvious from the nature of the problem that no absolute standard can be set up by which the safety of a ship can be judged. Any comparison which can be made must be relative only. Sir Westcott Abell devised such a method in his paper on "Safety of Life at Sea," presented to this institution in 1921, by comparing the chances of loss of bulkheads. Some comparisons have been made on similar lines considering only the chances of loss of such number of bulkheads as will open to the sea more than the floodable length.

The factorial method is not altogether reasonable in its practical application. When various factors of subdivision are applied to any particular length of ship there exist certain points at which, in order to fulfil the required conditions, it is necessary to introduce one and perhaps more additional bulkheads which in effect produce locally a spacing which is within the limits of a higher factor of subdivision. This closing up of bulkheads obviously increases the chance of damage to more than one bulkhead, and under some circumstances will lead to more extensive flooding of the ship. The diagrams C and D (Fig. 1) illustrate this point.

Arrangement C conforms to the standard recommended by the shipowners, *i.e.*, two-compartment with a 10 per cent. margin. Arrangement D is what would result if the same number of boilers and the same oil fuel capacity had to be provided on a subdivision factor of 0·34. In the former case in a total length of 320 ft. it has been possible to arrange 30 boilers in four boiler-rooms with a series of small oil bunkers at the ship's side, which constitute an unbroken inner skin for the whole length.

In arrangement D, owing to the smaller factor of subdivision, additional bulkheads have to be introduced, and in order to install the same power the boilers have to be arranged five abreast, which makes it impossible to provide the protection of an inner skin. Moreover, if the same quantity of oil fuel is to be carried as in arrangement C an additional cross bunker must be fitted at the fore-end of the boiler-rooms, which occupies space which in arrangement C can be used for other purposes. The contrast between the two in respect of resistance to damage is very marked. The inner wall of the oil tanks is 12 ft. to 15 ft. from the ship's side, so that in all cases, except perhaps very violent collision, the effect of damage to the shell will be confined to the oil fuel tanks. In arrangement D even small damage to the shell in wake of a boiler-room would have quick and serious results, but the most significant point is the comparative result of

*A Paper read at the Summer Meeting of the Institution of Naval Architects, held in Holland, September 3, 1923.

a long ripping blow, which in C would probably be confined to the side tanks, but in D would flood two boiler-rooms and one cross bunker. The extent of flooding in the two cases is shown by the shaded areas in the diagrams. This constitutes one of the most serious objections to decrease of factor as a means for providing an apparent increase in safety. Another practical point which must be kept in mind is that in the event of oil fuel running short or its price becoming prohibitive, the side bunkers provide the only possible chance of reverting to coal burning. Taking these facts into consideration it can be seen that the factor of subdivision is not a sensitive criterion of a ship's immunity from disaster.

A considerable number of designs have been examined with a view to estimating their comparative safety when arranged so as to conform to the standards of the Convention and the shipowners' proposals, respectively. In each comparison the arrangement of bulkheads was arrived at after due regard to practical requirements. The conclusion reached is, perhaps, not unexpected, viz., that up to a certain length of damage assumed there is nothing gained by working to a 0·34 factor as compared to 0·45, and assuming that immediate loss

Fig. 2. DIMENSIONS OF SHIP 965'0" × 105'0" × 65'0" × 38'0" DRAUGHT. ARRANGEMENT A.

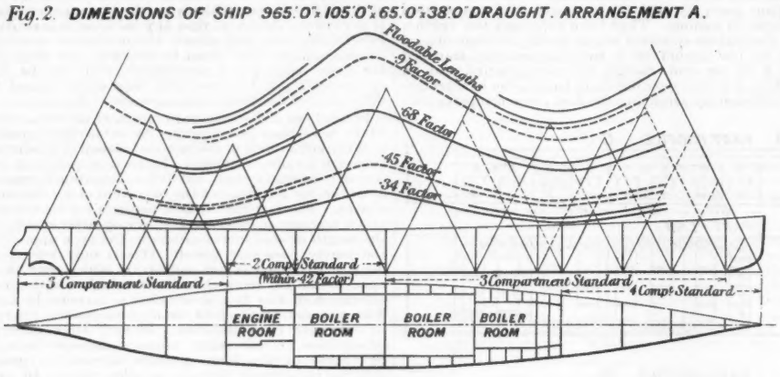
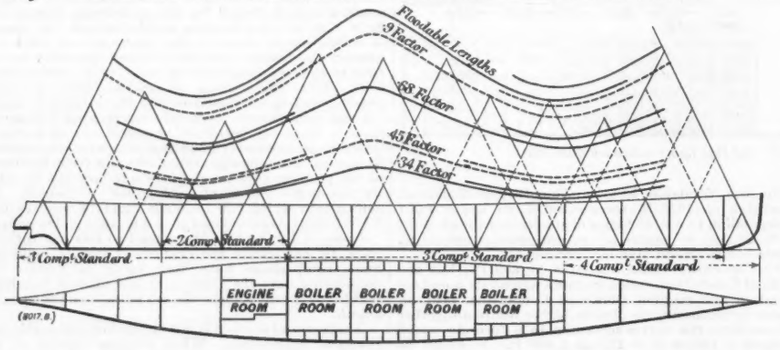


Fig. 3. DIMENSIONS OF SHIP 965'0" × 105'0" × 65'0" × 38'0" DRAUGHT. ARRANGEMENT B.



through destruction of all reserve buoyancy is the correct criterion for big ships. Beyond this certain length of compartment which increases with increase in length of ship, the advantage naturally lies with the smaller factor. In a vessel of the Aquitania size there is nothing to choose between the two with an assumed length of damage of 44 ft. at any point in the length of the ship. In a vessel 965 ft. by 105 ft. by 65 ft., designed to conform to a factor of 0·45, the "safe length of damage" is nearly 80 ft.

At the Washington Conference considerable stress was laid on the greater likelihood of damage being sustained at the fore end than at the after end of the ship. If comparisons are made considering the forward half-length only in each case there is generally a higher safe length common to the two arrangements. In some cases, with assumed damage of big proportions, danger zones occur in the 0·34 arrangements where they do not in the case of a similiar ship designed on a 0·45 factor. Another marked tendency was observed, which can be traced to the small choice in length of boiler-rooms which is available to the designer, that is, that over a range of lengths designs, which conform to a 0·34 standard in actual practice, come within the limits of a 0·31 factor.

There are an infinite number of different arrangements of bulkheads possible within the limits of a particular factor of subdivision, all of which will afford a different degree of immunity from loss for any assumed length of damage. The significance of this method of comparison depends principally on the length of under-water damage assumed, as any variation in respect of permeability may reasonably be assumed to be common to the two cases compared. The only indication in the Convention as to longitudinal extent or damage which was taken into consideration is the lower limit of length of compartment, viz., 10 ft. Sir Archibald Denny, in the discussion on Sir Westcott Abell's paper already referred to, stated that the average length of torpedo damage, viz., 40 ft., was too great a length to be assumed. It seems, therefore, that if the object of the Convention is to cater for normal, as distinct from abnormal circumstances, there is no advantage in imposing any more stringent standard than that recommended by the shipowners.

To illustrate the effect of the factorial system as applied to very large ships, flooding diagrams are given for two different arrangements of bulkheads in ships of equal dimensions, each of which have resulted purely from considerations of design. The position of none of these bulkheads can be altered without prejudice to the ship as a commercial asset. In arrangement A (Fig. 2) the factor necessary for the spacing of bulkheads is approximately 0·42, but the forward half-length of the ship conforms to a three-compartment standard and the four forward compartments come within the floodable length. In arrangement B (Fig. 3) the necessary factor is again approximately 0·42, but the actual spacing of bulkheads indicates a three-compartment standard right up to the after end of the machinery space.

The converse of this curious state of affairs, namely that if the ship conforms to a three-compartment practically throughout it can be built under a factor of 0·33 does not hold good. It will be seen in each of the diagrams that the critical points occur at each end of the machinery spaces. The important point is that the length of the midship superstructure, in which is bound up a large percentage of the earning power of the ship, is determined by the length of holds immediately before and abaft the machinery spaces.

These results show clearly that the factorial method applied to big ships provides no indication of the standard that may be obtained in actual practice. It would be interesting to know the opinion of this representative body as to whether the standard of safety embodied in these two arrangements is considered as fulfilling the spirit of the Convention that the ships would be subdivided as closely as possible having due regard to the service for which they are intended.

As a general rule nothing can be gained by arguing about general principles on a basis of particular cases. The defence in this instance is that vessels of the largest size are always particular cases, and the force of this argument is enhanced for this very reason. In no other case has any attempt been made to formulate statutory requirements of a quantitative nature to be applicable to vessels of extreme dimensions. As for example, the proposed new load line regulations stop at 600 ft., whilst the rules of the various classification societies do not attempt to deal with ships approaching the size of the largest types.

The suitability of safety of life at sea as a subject for international legislation is in itself a very doubtful question. It has been assumed that the safety of the travelling public is a matter of national concern, but it is a moot point whether it is reasonable to expect full agreement on such subjects. The traveller in the majority of cases is the least conscious of the risks he takes. If he examines his chances at all it is at best only subconsciously. The careful traveller, in summer at any rate, would elect to go from Glasgow to London by sea if he wanted to take a minimum of risk, but such a procedure would be considered absurd if undertaken with that object in view. Marine disasters of the first magnitude are mercifully rare, and the increased aids to navigation now available in the nature of radio-telegraphy and direction-finding should still further reduce the chances of their recurrence.

In 1914 the British Government took the lead in enforcing the provisions of the Convention. At that time no one, I think, anticipated the full consequences of this action. It has been proved, however, beyond doubt that it is in the common interest of all nations to come to full agreement as to the form which any revision should take. When dealing with such matters internationally I believe that the only hope of obtaining this agreement lies in the establishment of a standard which obviously provides adequate security and just as obviously will not prove economically unsound in its operation. Any further elaboration can more appropriately be dealt with by each individual State.

It has up till now been the privilege of the few to be able to build very large steamers, the total number built in the last 35 years being comparatively small, and the future holds out no prospect of their number being very largely increased, but I would again emphasise their importance in commerce and communications generally. The magnitude of the undertaking involved in laying down such vessels is so far-reaching as to be out of all proportion to the significance of mere formulæ. The economic needs of the times have to be carefully weighed and the cost involved estimated within very narrow limits before embarking on such an enterprise.

In designing big ships in the future much will depend on developments in the type of propelling machinery. It is not unlikely that for some time yet steam will have to provide the power, and whilst water-tube boilers of the small tube type are entirely unsuitable for merchant ships, no appreciable economy of space results from using the large tube type in place of the cylindrical boiler. The result is that even with a high degree of superheat and all modern improvements, a very large number of boilers have to be accommodated. It is, however, quite possible that our ideas as to the propelling machinery for big vessels may undergo a radical change in the next few years.

I am of the opinion that whilst subdivision is undoubtedly the primary consideration it is unnecessary to evolve detailed legislation dealing with that part of the problem which in the nature of things will in every particular case be subjected to the closest possible scrutiny by the best experts. It is impossible to coerce any Government to abide by international rules or prevent them building ships to a lower standard if, in their opinion, economic considerations demand it. But this, unfortunately perhaps, will not deter passengers booking berths in such ships. It is quite possible that international agreement could be obtained on the standards set out by the shipowners, and from the arguments put forward in this paper it is not unreasonable to claim that adequate safety is provided by these proposals. Some credit ought to be given to owners for the will to achieve the greatest possible measure of safety consistent with economic requirements. The incentive to do so is very great for obvious reasons, as the loss of a big ship means financial loss immeasurably greater than the value of the ship, to say nothing of the loss of reputation involved. There may exist in some minds the feeling that any proposal, apparently, to relax the standard for big ships is made not entirely from disinterested motives. I can only express the hope that the contents of this paper will serve to stem such a trend of thought.

In conclusion I would like to thank Mr. L. Peskett and Mr. G. McL. Paterson for their assistance in the preparation of this paper.

CATALOGUES FOR MEXICO.—His Majesty's Consul-General at Mexico City (Mr. N. King) wishes to draw the attention of British traders sending catalogues to Mexico to the necessity for arranging for the payment of the recently imposed duty on such literature. It should be noted that delivery is not permitted before this duty has been paid.

GERMAN SHIPBUILDING SINCE THE WAR.—In the German shipbuilding industry, the yards began new work on a small scale soon after the war, but matters were considerably accelerated in 1920 by the Government grant for the reconstruction of the German merchant navy, although this proved altogether inadequate. The yards, however, have never been fully employed since the war; at present the position is very difficult, as new orders have practically stopped. The following figures show the tonnage finished at German yards during the last three years:—1920, 290 vessels, of 327,700 gross registered tons; 1921, 343 vessels of 450,900 gross registered tons; 1922, 648 vessels of 742,100 gross registered tons. Of these the following tonnage was for German account:—1920, 243,000 gross registered tons; 1921, 409,900 gross registered tons; 1922, 710,100 gross registered tons. Vessels finished for foreign account were as follows:—1920, 40 vessels of 84,700 gross registered tons; 1921, 54 vessels of 41,000 gross registered tons; 1922, 37 vessels of 32,000 gross registered tons. The tonnage of motor vessels built shows a material increase, from 73,000 tons in 1920 to 135,000 tons in 1921 and 121,000 tons in 1922. Foreign owners ordered 102,500 tons from German yards in 1922.

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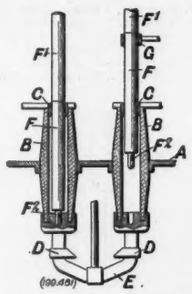
ELECTRICAL APPARATUS.

199,461. A. Reyrolle and Co., Limited, Hebburn-on-Tyne, and H. W. Clothier, Wallsend. Electric Switches. (4 *Figs.*) March 22, 1922.—The invention relates to oil-break switches used on high voltage systems. According to the invention, the conductor passing through the insulator supporting the fixed switch contact is movable, such as capable of sliding, so that whilst in one position it serves as a connection between the contacts at the ends of the insulator, in another position to which it is moved or withdrawn, it acts as an isolating device. A is a portion of the top or cover of a switch tank supporting in the usual way two hollow insulators B. At the upper end of each insulator B is a sleeve C through which connection is made from the adjoining parts of the circuit. The insulators B carry at their lower ends



the fixed contacts D of a switch E. Within each hollow insulator B is a rod F having a handle F1 of insulating material. As shown in the left-hand portion of the figure, the member F in its normal position makes connection between the sleeve C and the fixed contact D, the lower end of the member F being formed as at F2 to make a plug connection with the metallic fitting at the lower end of the insulator. The right-hand side of the figure shows the member F partially withdrawn, thus isolating the contact at the bottom of the insulator. By way of example the right-hand side of the figure shows how, if desired, the isolating member F can also act as an earthing device by making contact with a sleeve or brush G connected to some convenient earthed point. (*Accepted July* 4, 1923.)

GAS ENGINES, PRODUCERS, HOLDERS, &c.

199,540. Sir H. Austin, Bromsgrove. Internal-Combustion Engines. (2 *Figs.*) April 18, 1922.—The invention relates more especially to internal-combustion engines in which the crankshaft is mounted in roller bearings. According to the invention, one of the cranks in respect of each big-end has a recess C formed in that face which is toward or away from the direction of rotation, and this recess connects by internal passages C2 with an oil hole C3, in the respective crank-pin. The recess C in the crank, as the latter revolves, comes periodically

Fig. 1.

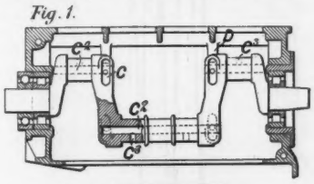
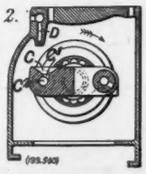


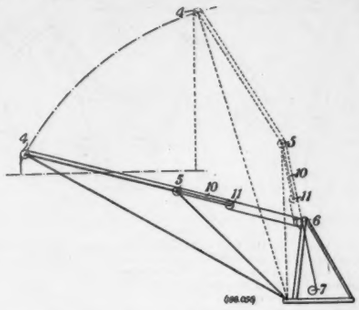
Fig. 2.



directly in the path of oil, which is caused to issue and fall freely from, or be projected from, a nozzle or aperture D fed from a suitable pump or other source. Preferably the nozzle is so arranged that the oil descends from it vertically and falls into the recess C as the latter passes the horizontal on its upward movement. The recess may, however, be made in the other face of the crank, in which case it collects the oil on its downward movement. The oil from the recess is forced by centrifugal force from thence to the oil hole or holes in the crank-pin, in a well-known manner. (*Accepted July* 4, 1923.)

LIFTING AND HAULING APPLIANCES.

196,056. E. Griffiths, Whitley Bay, and Armstrong, Whitworth and Co., Limited, Newcastle-upon-Tyne. Cranes. (2 *Figs.*) January 11, 1922.—To maintain the load at a fixed height during luffing, the hoisting rope passes from the load over a sheave at the jib head, thence round a sheave on the crane superstructure, and then back to an intermediate sheave mounted on the jib above the line joining the jib head and jib pivot, the rope being reeved as many times as desirable round the superstructure and intermediate sheaves before passing to the winding drum. The figure shows the invention applied to a crane of the type in which the jib forms an isosceles triangle. The hoisting rope passes over the single head sheave 4 and guide



sheave 5 at the apex of the triangle to one of a series of sheaves 6 at the top of the post, and then is reeved as many times as is necessary round sheaves 11 connected by a link 10 to the apex of the jib and the sheaves 6 before passing to the winding drum 7. In a modification, the link 10 and sheaves 11 are omitted, and the rope is reeved directly round the multiple sheaves 5, 6. (*Sealed.*)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

199,432. G. W. Berry, Wakefield. Flanging and Double Seaming Mechanism. (6 *Figs.*) February 27, 1922.—The invention relates to mechanism for applying covers or ends to sheet metal receptacles by the combined operations of flanging and double-seaming the metal at the joint. *a* is a chuck mounted on a spindle a^1 operated by a treadle whereby the chuck *a* may be lifted to bring the body of the receptacle with the cover shaped as shown in Fig. 3 against an upper chuck *b* capable of being rotated. The chucks *a*, *b* are rotated by any suitable means (not shown). The chuck *b* receives the pressure of the rollers hereinafter described. Adjacent to and at one side of the parts described is a support for the various flanging and seaming implements which are in the form of rollers. This support is in the form of a casting *c* rotatable about a column c^1 and having at its upper end a collar c^2 provided with a projection c^3. At its lower part the support *c* has a bracket d^2 to carry a horizontal pressure roller *d*. Above the roller *d* the support is provided with a recess e^1 in which slides a spindle e^2 under the action of a coiled spring e^3 and carrying a vertical flanging roller *f* rotatable on said spindle. To the rear of the roller *f* the support *c* carries two other horizontal rollers *g*, *h* located in a plane approximating to that of the pressure roller *d*. At the side of the support *c*, remote from the rollers, is an operating lever *i* fulcrummed on the support and pivotally connected to an end of the spindle e^2. The lever is extended beyond the connection with the spindle e^2 and engages one of two recesses j^1, j^2 formed in a trigger *j*. The operating lever *i* is moved until the flanging roller *f* engages the lip o^1 of the cover, lateral pressure being taken by the roller *d* in contact with the top of the receptacle as indicated in Fig. 1. The corresponding position of the lever and of the flanging roller *f* is indicated in broken lines in Fig. 2, in which the outer end of the lever *i* is shown in engagement with the recess j^1 of the

Fig. 1.

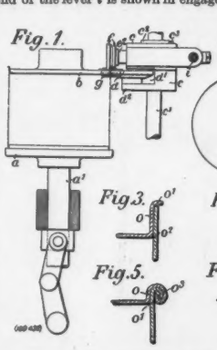


Fig. 2.

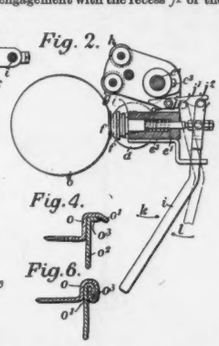


Fig. 3.

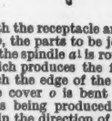


Fig. 4.

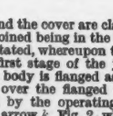


Fig. 5.

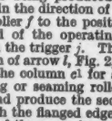
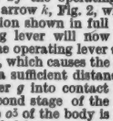
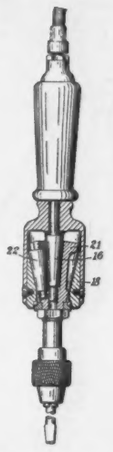


Fig. 6.



trigger *j*. Both the receptacle and the cover are clamped between the chucks *a*, *b*, the parts to be joined being in the position shown in Fig. 3, and the spindle a^1 is rotated, whereupon the operation is performed which produces the first stage of the joint shown in Fig. 4, in which the edge of the body is flanged as at o^3 and the edge o^1 of the cover *o* is bent over the flanged edge o^3 of the receptacle, this being produced by the operating lever *i* being slowly moved in the direction of arrow *k*, Fig. 2, which will move the flanging roller *f* to the position shown in full lines in Fig. 2. The outer end of the operating lever will now have engaged the recess j^2 in the trigger *j*. The operating lever *i* is now moved in the direction of arrow *l*, Fig. 2, which causes the support *c* to be swung about the column c^1 for a sufficient distance to bring the grooved curling or seaming roller *g* into contact with the joint so far made and produce the second stage of the joint shown in Fig. 5, in which the flanged edge o^3 of the body is curled and the outer edge o^1 of the cover is curled between the edge o^3 and the wall of the body, this operation effecting the known form of double seam. The movement of the support *c* as described removes the flanging roller *f* and pressure roller *d* completely away from the receptacle, and still further movement of the lever *i* in the direction of arrow *l* rocks the support *c* still further on its axis c^1, whereby the seaming roller *g* is passed away beyond the receptacle and the final flattening roller *h* is brought into contact with the work to produce the final and finished flattened double seamed joint shown in Fig. 6. At the end of this operation the trigger *j* comes into contact with projection c^3, which trips the trigger, releases the end of lever *i* from recess j^2, and allows the flanging roller *f* under the action of spring e^3 to return to original position ready for another operation, the lever end at the same time snapping into the first recess j^1 of the trigger. (*Accepted July* 4, 1923.)

197,396. R. W. J. Fletcher, Edinburgh. Transmission Gearing for Machine Tools. (3 *Figs.*) February 9, 1922.—The type of gearing to which the invention relates is that comprising a sun-member and an epicyclic roller so mounted in relation to each other that they can be pressed into operative driving engagement with each other when the tool is pressed against its work, whilst at other times (i.e., when the said pressure is relaxed) they are free to slip. According to the invention, there is provided in or for a machine-tool or other shaft-driven member, a transmission gearing of the type described, charac-



terised in that both the sun-member 16 and the epicyclic roller or rollers 22 co-acting therewith are of conical formation so mounted in relation to each other that when pressed into operative driving engagement with each other they make line contact one with another and their apexes are situated at or substantially at a point common to them all. A preferred construction of gearing of the type described comprises a conical sun-roller 16, conical planet rollers 22 loosely carried in a cage 21 to rotate about the sun-roller, and a co-operating conical surface 18 enclosing the planet rollers and arranged to be operatively engaged thereby. (*Sealed.*)

MINING, METALLURGY AND METAL WORKING.

196,958. L. H. Bonnard, Ealing, London. Retorts and Furnaces. (7 *Figs.*) December 3, 1921.—In a mechanical furnace or retort for the treatment of mobile materials such as sludge, ores, sawdust and decolorising carbon, having a number of superposed trays or hearths over which the materials are moved by rabble blades, arrangements are provided for raising and lowering the blades so that they act alternately to spread the material and to move it over the trays. The blades 17 are mounted on a rotary shaft 16, which is driven through gearing 21, 22, and is raised and lowered by the engagement of rollers 19 with a fixed face cam 20. The pressure on the cam is reduced

Fig. 1.

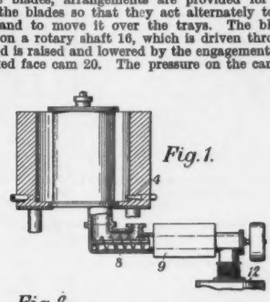
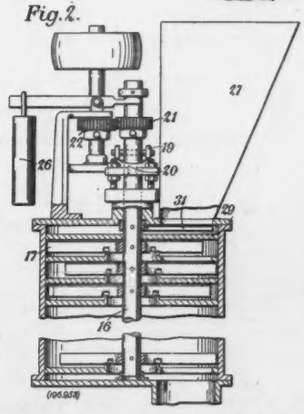
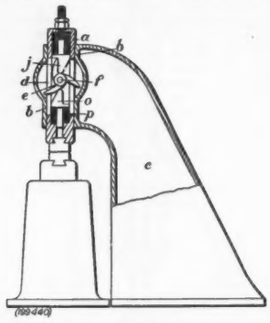


Fig. 2.



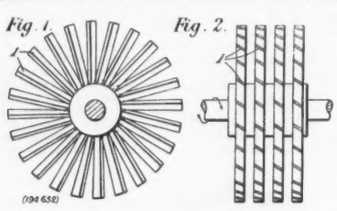
by counterbalancing the shaft by means of a weight 26. When the blades are lowered to contact with the trays more than once in each revolution, the number of blades for each tray should be incommensurable with the number of times of contact. The material is fed from a hopper 27 on to a plate 29, and is swept through a drop opening therein by an arm 31 on the shaft. The retort is heated by tangentially arranged burners 4, and the material is discharged by a screw 8 into a sealed receiver 12 connected to the conveyor casing by an expansion pipe. The material is cooled by a water jacket 9 around the conveyor casing. (*Sealed.*)

199,440. Jackson Brothers (Sheffield), Limited, Sheffield, J. C. Jackson, Hillsborough, Sheffield, and G. Glossop, Hillsborough, Sheffield. Power Hammers. (2 *Figs.*) March 16, 1922.—The invention relates to power hammers of the type in which the tup is operated by a cam arranged within the tup, and is characterised in that the cam is adapted to give an additional downward impulse to the tup in its fall by gravity when striking each blow. The tup *a* moves in guides *b*, *b* in a standard *c*. The tup is slotted at *d* to receive a three-winged cam *e* mounted on a shaft *f*. Within the tup *a* and resting on the cam *e* is a sliding spring-pressed member *j*. A second sliding spring-pressed member *o* is disposed on and bearing against the underside of the cam. In use, as the cam is rotated anti-clockwise the spring-pressed member *j* is pushed upward by



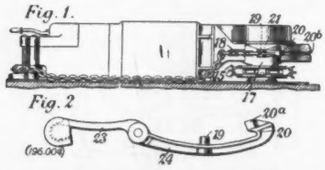
one of the wings of the cam, thereby raising the tup *a*, meanwhile the spring-pressed member *o* is pressed downward and released by the next following wing of the cam and again pressed downward by that wing of the cam preceding the one actually raising the tup. As the member *j* travels upwards to the highest point of the cam a certain amount of compression in the spring *p* is stored up due to the combined action of the downward movement of the member *o* towards the bottom of the tup and the upward movement of the tup, and as soon as the member *j* is released, which thereby frees the tup at the top of its stroke to drop by gravity, the spring *p* acting on the base of the tup, gives the tup an additional downward impulse in its fall. After each blow, rebound takes place against the spring *p*, which is only lightly loaded, and the above operation repeated. (*Accepted July* 4, 1923.)

194,652. The Powdered Fuel Plant Company, Limited, Westminster (*The Assignees of Société Anonyme de La Combustion Rationelle, Paris*). **Fuel Pulverising Apparatus.** (2 *Figs.*) March 8, 1922.—The invention provides improvements in or modifications of the invention forming the subject-matter



of Letters Patent No 181,290, and consists in making the vanes 1 of the rotor of helicoidal shape from root to tip, each carrier or disc thereby constituting a low-pressure fan. The complete rotor therefore comprises a series of turbo-fans that act in succession on the air, each having to overcome only elemental resistance. (*Sealed.*)

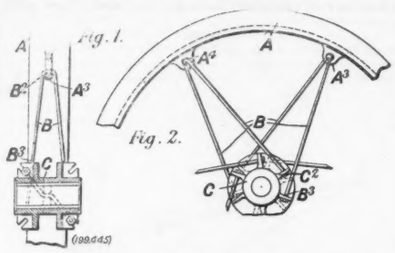
196,004. G. Rimmer, London. Coal-Cutting Machines. (5 *Figs.*) October 15, 1921.—In a coal-cutting machine of the chain-cutter type adapted in operation to haul itself along a chain, which chain may also be used to slue the jib, the chain is connected to the jib by a connecting member comprising two or more links pivoted about an axis transverse to the plane of the jib, the member being sufficiently inflexible in a direction towards the jib as to prevent fouling of the cutter chain. The connecting member may comprise a hook 20 engaging a projection



17 on the jib and having a pin 19 engaging a slot 21 in the projection 17, together with a chain 18 which is inflexible vertically and may be of a limited flexibility in the horizontal plane. In a modification, the connecting member comprises two pivoted links 23, 24, of which the hook 20 has a projection 20a engaging a groove 20b in the machine frame and co-operating with the pin 19 to hold the connecting member in a horizontal plane. The connecting member may be secured by means preventing rotation thereof; *e.g.*, the pin 19 may be squared and engage a squared recess. (*Sealed.*)

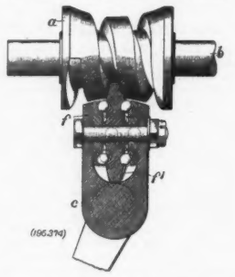
MOTOR ROAD VEHICLES.

199,445. W. H. W. Proctor, Coventry. Wheels. (9 *Figs.*) March 18, 1922.—The invention relates to wheels of the kind in which the spokes are formed in U-shaped pairs, each pair constituted by forming a hairpin bend in the material of the spoke, the spokes being secured at their ends to the hub and the rim. The free ends B3 of the spokes B are attached to the wheel hub C at opposite ends respectively and lugs A3 are provided around the inner periphery of the rim A. In each lug a hole A4 is provided so that the spoke can be threaded through it, and when in position, engages it at the bend B2, the lug being of appropriate thickness for this purpose to avoid slackness of the spoke sideways of the wheel. The bend of the double spoke is such that, in addition to straddling the hub, its limbs meet the latter tangentially upon each side of the wheel as is shown in Fig. 2, and thus it will be evident that by the employment of a suitable number of these double spokes, a strong tangentially built wheel will result, having also great lateral stiffness through the axial spread of the spokes at the hub. The lugs C2 upon the hub C



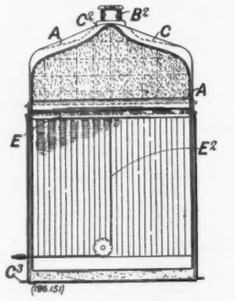
for engagement by the free ends B3 of the spokes are preferably in the nature of radial tooth-like projections, well buttressed on one side, and on the other having a face square to the spoke-axis for engagement by the nut which is threaded upon and tightens up the spokes. Holes or slots are formed in the projections for receiving these spokes. (*Accepted July* 4, 1923.)

196,374. The Maries Steering Company, Limited, London, and H. Maries, London. Steering Gear. (6 *Figs.*) January 21, 1922.—Steering gear comprises a helical cam *a* mounted on the steering shaft *b* and a rocker shaft *c* carrying one or more rollers *f* adapted to engage the cam with the marginal portions of one or both of its (or their) side faces *f*1. The roller



may engage one face of each of two adjacent threads of the cam, or a groove in the roller may engage the two faces of a single thread. The steering-shaft *b* may be placed between the rocker shaft and the roller, in which case the cam instead of being hollow-shaped or waisted as shown is barrel-shaped. (*Sealed.*)

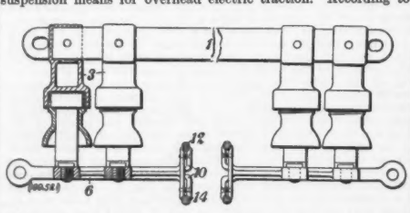
196,151. The Standard Motor Company, Limited, Coventry, and G. A. Phillips, Coventry. Radiators. (2 *Figs.*) March 3, 1922.—Radiators for use with internal-combustion engines, more particularly those of motor vehicles, are provided with an adjustable shutter E carried by a removable frame A to which is also attached padded and heat-insulating fabric or like material C, as shown. The filler tube B2 fits through an aperture C2, which serves to locate and secure the frame



and fabric to the upper part of the radiator. Tabs C3 and suitable fasteners are also provided to secure the radiator protector in a readily removable manner. The shutter E is a spring controlled blind worked by a cable E2 extending to a position where it can be conveniently manipulated by the driver, such as to the steering column. A hood or projecting lip (not shown) may be provided to protect the blind when in the inoperative and rolled-up position. (*Sealed.*)

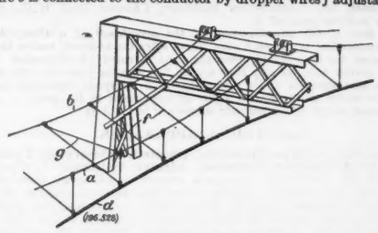
RAILWAYS AND TRAMWAYS.

199,521. N. Clough, Westminster. Systems of Electric Traction. (3 *Figs.*) April 5, 1922.—The invention relates to suspension means for overhead electric traction. According to



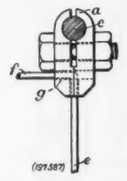
the invention, suspension means comprise a horizontal carrying member 1, a hanging member 3 depending therefrom at right angles and a supporting member 6 carried by the hanging member 3 parallel with the horizontal carrying member 1 and of T-shape, with means 10 at each end of the head or transverse member of the T to grip a member of the conductor constituted of two parallel or substantially parallel members 12, 14 disposed the one above the other. The hanging member 3 constitutes means to insulate the horizontal carrying member 6 from the supporting member 1. (*Accepted July* 4, 1923.)

196,528. Sir P. Dawson, London, and W. Fawdry, South Kensington. Suspending Overhead Conductor Wires. (5 *Figs.*) July 26, 1922.—One of the catenary wires of a triangular suspension system is slewed in relation to the conductor, when the latter is to follow a curved path. The catenary wire *a* is approximately vertically above the conductor *d*, and the slewed catenary wire *b* is connected to the conductor by dropper wires *f* adjustable



in length for the purpose of curving the conductor. On straight portions of the track the catenary wires are slewed on opposite sides of the conductor over alternate lengths of the track to secure a zig-zag disposition of the conductor whereby the wear on the collecting bow is distributed over its length. On sharp curves a pull-off wire *g* is arranged to maintain the catenary wire *a* vertically above the conductor at the centre of the span. (*Sealed.*)

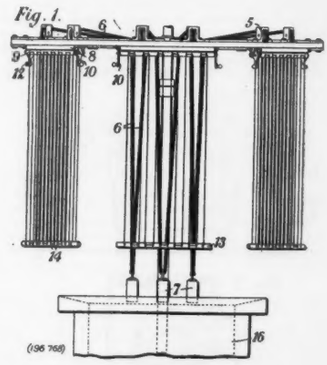
197,587. Sir P. Dawson, London, and F. W. Fawdry, South Kensington, London. Supporting Overhead Conductors. (2 *Figs.*) July 26, 1922.—The invention provides an improved form of clip for attaching dropper wires to the catenary or messenger wires. According to the invention, the dropper wire *e* is formed at its upper end with a bent portion *f* extending



at right angles to the direction of the catenary wire *c*, such bent portion passing through an aperture *g* formed in one of the plates *a* forming the clip in such a manner that the plates can be clamped together for attachment to a catenary wire and to lock the dropper wire in place in one operation. (*Sealed.*)

MISCELLANEOUS.

196,768. W. H. Day, Hounslow, and R. G. Sanrey, Hounslow. Candle Dipping Machines. (10 *Figs.*) March 9, 1922.—A candle-dipping machine comprises a number of counter-balanced wick-frames arranged round an overhead horizontal framework that can be rotated so as to bring each wick frame in turn over the dipping tank. Means are provided for adjusting the length of the wicks in each frame, and preferably the wick-thread is continuous throughout each frame, and a gauge plate is provided on each frame for surfacing the candles. In the machine shown, the upper members 9 of the wick frames are detachably secured by hooks 10 to carriers 8 on the outer ends of



the pairs of cords 6 which run over pulleys 5 on the rotating framework and which carry counterweights 7. The lower members 13 of the wick frames are supported the desired distance from the upper members 9 by arms adjustable on rods that are temporarily hung from knobs 12 on the hooks 10, until the wick is threaded between the hooks 14 of the members. The gauges, consisting of plates with circular holes the size of a finished candle, are detachably secured to the members 9. Each frame is dipped in the tank 16 by the operator pulling down the knobs 10. It is then raised by its counterweight 7, and turned aside to cool while the remaining frames are dipped. (*Sealed.*)

UNIVERSITY COLLEGE OF SWANSEA.—The prospectus of the Department of Engineering, for the session 1923–1924, is now available. The courses begin on Tuesday, October 2, and end on Monday, June 30, 1924. They cover such subjects as engineering, mathematics, physics, chemistry, geology and metallurgy, etc. The college is in Singleton Park, Swansea.